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METHODOLOGY FOR PROJECTION OF OCCUPATIONAL TRENDS IN THE DENVER STANDARD METROPOLITAN STATISTICAL AREA.

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VARIOUS METHODS AVAILABLE FOR A PROJECTION OF OCCUPATIONAL REQUIREMENTS OF A STANDARD METROPOLITAN STATISTICAL AREA (SMSA) ARE REVIEWED, AS WELL AS THE DATA AVAILABLE TO IMPLEMENT THESE APPROACHES. TWO "NAIVE" MODELS ARE RECOMMENDED FOR USE AS BENCH MARKS AGAINST WHICH TO COMPARE MORE SOPHISTICATED APPROACHES--THE "NO CHANGE" MODEL AND A MODEL WHERE THE SMSA CHANGE IS ASSUMED TO BE THE SAME AS THE NATIONAL CHANGE. FOUR SOPHISTICATED MODELS ARE CONSIDERED--(1) THE HISTORICAL, WHERE THE SMSA IS CONSIDERED SO DIFFERENT FROM THE UNITED STATES OR OTHER SMSA'S THAT IT MUST BE TREATED AS A SEPARATE, UNIQUE ENTITY, (2) THE "IDEAL" TYPE MODEL, WHERE INDUSTRIES ARE GROUPED INTO SIGNIFICANT CATEGORIES (E.G., PRIMARY, SECONDARY, TERTIARY), (3) THE METHOD THAT STRESSES OCCUPATIONAL GROUPINGS (E.G., WHITE COLLAR, BLUE COLLAR, SERVICE, AND FARM WORKERS), AND (4) THE METHOD THAT RELATES THE SMSA TO THE NATIONAL ECONOMY. THE TWO MAIN APPLICATIONS OF OCCUPATIONAL PROJECTIONS ARE TO GUIDE EDUCATIONAL PLANNERS AND TO ADVISE ENTRANTS AND POTENTIAL ENTRANTS INTO THE LABOR MARKET. THE LONG-RUN AIM IS TO HELP RATIONALIZE THE OVERALL LABOR MARKET. THE "BEST" PROJECTIONS FOR EDUCATIONAL DECISION-MAKERS ARE THOSE THAT WOULD GROUP OCCUPATIONS BY COMMON BACKGROUND REQUIREMENTS AND THOSE THAT WOULD HELP PREPARE CURRICULUMS FOR AN AUTO MAKING AND MOBILE ECONOMY. APPENDIX I REVIEWS THE LITERATURE ON EMPLOYMENT PROJECTIONS AND THE DATA AVAILABLE FOR MAKING THESE PROJECTIONS IN THE DENVER SMSA. APPENDIX II DEVELOPS AND APPLIES A METHOD FOR OCCUPATIONAL PROJECTIONS FOR THE DENVER SMSA USING THE MATRIX TOOL. (EL)

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Methodology For Projection Of Occupational Trends In The Denver Standard Metropolitan Statistical Area

by

Leslie Fishman, William E. Roberts,
Charles M. Franks and William W. McCormick

Prepared for the Office of Manpower, Automation and Training,
U. S. Department of Labor, Under Contract No. MDTA 42-64

BUREAU OF ECONOMIC RESEARCH
INSTITUTE OF BEHAVIORAL SCIENCE
UNIVERSITY OF COLORADO
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SUMMARY

This report reviews the various methods available for a projection of occupational requirements of an SMSA, the data available to implement these approaches, and recommends "best" methods to guide us in both methodology and in data collection. Appendix I reviews the literature on employment projections and also the data available for making these projections in the Denver SMSA. Appendix II develops and applies a method for occupational projections for Denver SMSA using the matrix tool. William E. Roberts was primarily responsible for Appendix I; Charles M. Franks and William W. McCormick were primarily responsible for Appendix II.

Two "naive" models are recommended for use as benchmarks against which to compare the more sophisticated approaches -- the "no change" model (A) and a model where the SMSA change is assumed to be the same as the national change (B). Four sophisticated models are considered: (C) the historical, where the SMSA is considered so different from the U. S. or other SMSA's that it must be treated as a separate, unique entity; (D) the "ideal" type model, where industries are grouped into significant categories (e.g., primary, secondary, tertiary); (E) the method that stresses occupational groupings (e.g., white collar, blue collar, service, and farm workers) and (F) the method that relates the SMSA to the national economy. The choice of "best" method depends on the data and on the purposes for which the projections are likely to be made. Since both the uses of the projections and the data compilation are changing over time, one of the main applications of this report might be to focus attention on the direction of change that should guide policy in these areas over the long-run.

The two main applications of occupational projections are to guide educational planners and to advise entrants and potential entrants into the labor market. The long-run aim is to help rationalize the overall labor market, which cannot be done unless demand projections are relatively accurate. The "best" projections for educational decision-makers are those that would group occupations by common background requirements and those that would help prepare curriculas for an automating and mobile economy. Although most apprenticeship programs relate easily to industries, recent reforms in

vocational education point to a "core" preparation that lends itself to an occupational approach.

The data presently available for detailed SMSA occupational projections is almost entirely limited to the decennial census. Estimates of the classification errors in this household survey indicate that another source, or sources, must be developed, if SMSA projections are to be within reasonable limits. The methods themselves are open to considerable question; when combined with data that is likely to have exceptionally wide accuracy bands (easily 10% to 50%), the projections are sometimes worse than no projections at all. Three alternative paths are open which would improve the occupational data at the regional level, and all three can be followed simultaneously: (1) Increase the size and detail of the MRLF by census. (2) Broaden the BLS search for occupational data, along the lines they have already begun, from professional societies, from regulatory agencies, and other similar sources. (3) Cooperate with businesses to standardize job descriptions, much as the steel industry has done, and begin to get automatic occupational data as a by-product of already existing reports (either the social security or the unemployment reports). In other words, if each social security number (or unemployment compensation deduction) included a job classification number too, then occupational statistics from industry would be automatically available.

Given the present needs of educational authorities and the present status of occupational data, the method that relies on occupational groupings appears to be both the most useful and the most reliable. Clearly, accurate industry break-downs are important and, if available, they would add immeasurably to the projections, but they are likely to be available only in the longer-run.

The review of the literature in Appendix I leads one to the potentially misleading conclusion that industry surveys of occupational projections are most questionable. When checked against naive models they invariably have been second best. What must be recognized and emphasized is that individual employers, even when the survey is given priority and consideration by top management, can only reflect the individual company's outlook. What the statistician and economist must do is to devise ways to permit these potential decisions to interact with one another in the interrelated world in which we live -- or a model of that world sufficiently realistic to give good results. It is precisely this interrelatedness that is reflected in the matrix approach, which is so similar to the Input-Output method.

All four of the methods described in the report can be treated in matrix form, but only one was applied, and that is found in Appendix II. A word resume of the key, numbered formulas provides a good summary of the specific method which is only one of many that might be used.

(1) Page 146: the occupational profile of an industry is represented by a_{ij}^{t} at time t -- where i is the occupation and j is the industry. For example, the coefficient matrix value of secretaries in the machinery industry (except electrical) 35 for 1940 is 29.74 and equals $a_{6,2}$ (see Table 1, p. 165). This represents the number of secretaries divided by the total employment in the machinery industry.

(2) Page 149: the f_{ij} represent the rates of change in the occupational profiles over time. These changes are caused by technology, product mix, method changes, and other forces that affect the proportion of an industry's work force in a given occupation.

(3) Page 149: total employment for the economy as a whole is a function of the level of output of each of the j industries.

(4) Page 149: total employment for the economy as a whole is also a function of the occupational demands.

(5) Page 149: the occupational demands at a given time t will depend upon the occupational profile of each industry and the level of output of each industry.

(6) Page 151: employment in a given industry is a function of the output of that industry.

(7) Page 153: output of an industry can be treated as a time series and projected into future, predicted levels -- equation (8), page 156.

(8) Page 157: the level of employment of an industry j at a given future time period is a function of the predicted level of that industry's future output -- or, the industry's production function of the future.

(9) Page 157: the occupational employments of each industry in that future time period is the product of the predicted occupational profile (f_{ij}) and the predicted level of output (p_j).

The heart of this beginning model lies in projecting a cell of the occupational profile (secretaries in machinery) on the basis of the coefficients derived from the 1940, 1950, and 1960 censuses. The projected coefficient, when multiplied by a projected level of output of the machinery industry, gives the total projected employment of secretaries in that industry. This coefficient dropped in succeeding censuses from 29.74 to 25.33 to 22.06. The best curve fit for $f_{6,2}$ (p. 170) was a time exponential: $449.921\ t^{-0.73612}$ -- which is going downhill very fast, and would mean no secretaries in machinery in less than seven more censuses. But because of classification changes from one census to another, and because of a large number of employees not classified in later censuses, the adjustment coefficient (k_{ij}) for secretaries in machinery is greater than 1 -- 1.20626, and this increases the 1970 coefficient to 23.79 and for 1975 to 22.61. The original fit to the three values of the 1940, 1950, and 1960 censuses was the best of all occupations and industries, with a correlation coefficient of .999999 and a standard error of estimate of .000190. Neither of these figures mean much because the regression model assumptions are certainly not fulfilled by the data. All it means is that the coefficient declined between 1950 and 1960 at about the same rate as it declined in the previous ten year period.

The method, in summary, is simply projecting the occupational profile and the levels of output of each industry, and combining the two. In a more complete model, the final demands would be projected and anticipated, along with the changes in the production functions.

This first, tentative matrix method is only a beginning and does not really exhibit the great potentialities of this tool. It is the inter-relationships of occupations (via inter-industry inter-relationships) that can best be done with the occupation-industry matrix. For example, of a 10% increase in an industry appears warranted, the matrix can reveal what that 10% increase would require for the indirect needs of the industry, as well as the direct needs. A 10% increase in the machinery industry will result in a proportionate increase in secretaries for that industry, adjusted for changes in the production function -- but it will also result in an increase in secretaries for all other industries affected by the machinery industry. This the matrix can reveal and this is its great value.

A review of the data presently available for SMSA occupational projections, however, shows that we are not at all ready to consider a tool as sophisticated as the matrix. What is required now, as a first step, is to group occupations (or industries) into a few meaningful categories and work with these. Fortunately, this also appears to be the level of sophistication required for educational decision making. Therefore, let us begin here, and as the data improves, let it tend to support improvements in the method along the lines suggested by the matrix tool and the methods (D) and (E) outlined above. As we progress, methods (C) and (F) can be more fully utilized.

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METHODOLOGY FOR PROJECTION OF OCCUPATIONAL TRENDS IN THE DENVER STANDARD METROPOLITAN STATISTICAL AREA

INTRODUCTION

Major strides are being made on a national basis "to shed some light on the problem of achieving a balance between the aggregate supply and demand for labor. . . . The final stage of the program is the distribution of the industry employment estimates into occupational requirements based on projections of occupational patterns, by industry. This can be used to evaluate potential areas of substantial surplus or shortage, and provide the basis for occupational guidance and development of longer-run training programs."[1/] The main purpose of this study is to explore methods to accomplish these same occupational projections for a sub-area of the national economy, in this case the Denver Standard Metropolitan Statistical Area (SMSA).

When one moves from the national economy to an SMSA like the five-county Denver region, a fundamental shift in method is required. The national projections start with population and labor force estimates, assume a 3% or 4% unemployment rate and certain participation rates, and then obtain the number that will be employed. Without minimizing the problems involved in the projections of population, labor force, and unemployment, they are still of a lesser order, given this approach, than the problems of projecting industry and occupational changes. For the national projections to 1970 and 1975, the greatest variations are likely to occur in the interindustry coefficients and in the occupational profiles within the industries. Just the reverse is true for the Denver SMSA.

For the Denver SMSA occupational projections to 1970 and 1975, the greatest variation is likely to occur on the demand side -- with the attempted estimate of the level of economic activity and employment likely to prevail five and ten years from now. The Denver SMSA is a sponge-like labor market, with large in-migration when growth is rapid and with large out-migration when growth slows or becomes negative. From 1959 to 1963 the Denver labor force

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[1/] "The Federal Government's Program of Economic Growth Studies," Jack Alterman, Deputy Associate Commissioner for Economic Growth, Bureau of Labor Statistics, U. S. Department of Labor, Paper given at the Seventh Annual Forecasting Conference of the American Statistical Association, New York Area Chapter, New York, April 23, 1965, pp. 3-4.

grew at a very rapid pace, one of the most rapid in the nation. For the past two years, however, the labor force has leveled and contracted. At the SMSA level, particularly for a relatively isolated region like Denver with its special characteristics, occupational projections must begin with estimates of demand and end with estimates of supply, instead of vice-versa. Because projections of demand are open to large variation, the challenge to develop a fairly reliable method for the Denver SMSA is a great one. Although labor mobility eases considerably the need for occupational projections by SMSA, vocational training programs and educational policies do require regional and specific information, if they are to be guided by more than current demand and supply conditions and experienced hunches. The need is great. Preliminary exploration of methodology is in order.

This study begins with a general description of how the national input-output tables and occupational matrices might theoretically be applied to a specific SMSA. The second section details the data presently available for an SMSA occupational projection. On the basis of this data, two naive models are developed and evaluated. The third section explores more sophisticated models and compares them to the naive models. Finally, some conclusions and recommendations are made for future data collection and method explorations. A survey of the literature and data is found in Appendix I. A detailed development of one of the sophisticated matrix models is found in Appendix II.

"IDEAL" APPLICATIONS OF THE INPUT-OUTPUT TABLES AND THE OCCUPATIONAL MATRICES

The input-output tables for an economy, or a sub-region, detail the direct and indirect sectoral interchanges that take place during a given production period. If these sectors exhibit "significant" differences in occupational profiles, then use of the I-O table for occupational analysis should add greatly to the reliability of the analysis over use of gross totals (i.e. for the entire economy). Where the sectoring is not related to occupational differences, then it would be better to use the breakdown of occupations for the United States as a whole.

A study of the 82 sectors of the 1958 interindustry tables lends considerable a priori support to the view that significant differences do exist between occupational profiles of different industries. The sectors have not been delineated with occupational analysis in mind. However, the way in which SIC designations have evolved, and the way in which occupations have developed (largely within a given industry, except for technological break-throughs that apply to many industries, such as the computer) has meant that strong relationships between sectors (industries) and job profiles are likely to exist and persist. A part of this relationship stems from the physical differences in the industries, a part from the cultural and social differences that industries apply to themselves, and a part undoubtedly stems from pure immobility. But whatever the source of the differences, as long as they persist they are helpful in occupational projections. To make the argument concrete, it is assumed that the occupational requirements for livestock products (1), paints and allied chemicals (30), motor vehicles and equipment (59), and office supplies (82), are significantly different. Cowhands, farm laborers, meat buyers, auctioneers, dairymen, beekeepers, and accountants, among others, are needed in a certain proportion in the "livestock and livestock products" industry. Chemists, machine maintenance men, warehousemen, and accountants, among others, are needed in a certain proportion in the "paint and allied products" industry. Designers, mechanical engineers, tool and die craftsmen, automobile salesmen, and accountants, among others, are needed in a certain proportion for the "motor vehicles and equipment" industry. Warehousemen, salesmen, deliverymen, and accountants are needed, among others, in a certain proportion for the "office supplies" industry.

The tables for direct and indirect purchases among 82 industries are now available for 1958.[2] Ideally, an occupational profile for each of these "industries" would be developed for 1958. Projections for final demand in 1970 and 1975 could then be made. If projections for the technical coefficients for these two years have also been made and, concomitantly projections of the occupational profiles by industry, then all three could be combined to produce the occupational requirements for 1970 and 1975. The assumptions regarding growth, full employment, and labor force would be built into the final demand requirements. The assumptions regarding technological change, product change, and interindustry balances would all be manifested in the projections of the technical coefficients and the occupational profiles. All of these forces are interdependent and, in real life, interact with one another. But for purposes of analysis, manageability, and "rational" projection techniques, it is important to break them down into these separate steps. When the projections are brought together, they can then be added up, compared, examined from various points of view, and "adjusted" for balance, orderly development, and historical common sense. All of this is neither easy nor accurate. Change, by its very nature, is not likely to be either orderly or predictable. But change is what this is all about.

Let us return to our four "industry" examples in order to make the entire projection process more meaningful. Industry number 1, livestock and livestock products, includes the following primary products: meat animals, hides, wool, mohair, cattle feed lot operation (part of SIC 0729), poultry and eggs, butterfat and milk, and other livestock and products (horses, mules, bees, honey, beeswax, rabbits, and dogs). Also specifically included are animal work power and manure. Output includes the following secondary products and receipts: processed milk, farm-slaughtered meats, miscellaneous fur bearing animals (including mink and silver foxes), and farm rental income. It includes all of SIC code 013, and parts of 014, 0193, and 02. Turning now to the occupational data available from the census of 1960, breakdowns are available by industry (although not necessarily exactly the same industry) by both major occupation group and by detailed occupation. The major occupation groups involved in livestock would be "farmers and farm managers," and "farm laborers and foremen." There are, however, many also included in some of the other categories. A brief run-down of the detailed occupations included in "livestock" might be an easy way to indicate the overlappings. These include: accountants, airplane pilots, farm and home management advisors, foresters and conservationists, agricultural scientists, biological scientists, veterinarian auctioneers, foremen (n.e.c.), truck and tractor drivers, and the various farm categories themselves.

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[2] Survey of Current Business, November, 1964, pp. 10-29, and Appendices I and II, available from the Office of Business Economics, Department of Commerce, which give more detailed industry and final demand descriptions.

Let us assume that all of these data are comparable, available, and sufficiently accurate for the purposes of projections of occupational needs in 1970 and 1975. What then are the next steps? First, one must estimate final demand for the livestock products five and ten years hence (including bees and furs and wool and hides and butterfat and rabbits and pedigree dogs). These projections might be based on the information we now have on income elasticities covering previous periods. On the basis of the way we as consumers behaved in the past 15 years, some generalizations are possible regarding the probable diet of the population in 1970 and 1975, and our possible tastes regarding fish, fowl, beef, and eggs, and also for leather products, honey, furs, butter, cheese, ice cream, beeswax, and horses and mules. Such projections would, of necessity, include estimates for the rise of substitutes (like Corfam for leather), but consumer reception is impossible to anticipate, and corporate inventiveness even more difficult. There may be a return to butter, or there may be an even more improved frozen dessert that undermines the demand for cream. Artificial furs may continue their upward climb, as may diet fads, and there may even be such outrageous products as synthetic, low-calorie steaks. Some help in the forecasting of such projections is to be found in the historical series for the individual products or groups of products, estimates for income elasticities, and knowledgeable people in the industries involved who can usually anticipate major trends for the next few years. Placing such projections in an I-O framework permits substitution and complementary interrelationships to be taken into account, and permits estimates of likely areas of general expansion and contraction. The total estimates for final demand depends, of course, on the resources available in 1970 and 1975, the productivity of these resources, and the degree to which they are employed.

To translate final demand into occupational requirements, several steps must be taken. First, technical coefficients of labor requirements for each sector must be projected to 1970 and 1975. Once again one is at the mercy of historical series and knowledgeable production experts. Second, occupational profiles by industry must be projected to 1970 and 1975. Historical series by industry and by occupation would be needed, as well as great skill at anticipating the future. Given the occupational profiles in 1970, the final demand levels multiplied by the technical coefficients of labor would establish the occupational requirements. For our specific example, livestock and livestock products, the concrete steps would be as follows. First, from the 1958 I-O table one is able to derive the labor requirement for the livestock industry per million dollars of product. With an estimated change in product mix and technology (perhaps derived from a comparison of the 1947 requirements to those in 1958, as well as the historical series and opinions of knowledgeable experts), the new labor requirements are projected. Let us assume that a consistent and reasonably accurate occupational profile is available for the "livestock and livestock product" industry for 1950 and 1960. Projections based on these profiles, historical series, and experts, result in the occupational profile anticipated for 1970 and 1975. Putting this all together gives one the occupational projection. For example, a direct demand of $2 billion plus an indirect demand of $1 billion for livestock products in 1970, with a given product mix and a given productivity level and a given occupational profile, will result in the demand for, say, 100,000 farm laborers. Hopefully, some estimate of possible limits for the projections would also permit statements to the effect that it is more likely that 90,000 livestock farm laborers will be demanded than 110,000. Perhaps, it is more likely that final demand (direct and indirect) will fall short of the estimates than exceed the estimates; or perhaps it is more likely that productivity will be faster than anticipated rather than slower; or perhaps it is more likely that the product mix will tend toward less farm-labor using products than toward more farm-labor using products. Taken together this might mean that although 100,000 farm laborers for livestock is the "best" estimate, the likelihood of demand's exceeding 100,000 is less than the likelihood of its falling short. Any more precise statements than this would probably lie in the realm of fantasy, and perhaps even this exceeds by far anything that can be "calculated" for a good many years. But this is the general method for national occupational projections that appears to be most promising.

How can this be applied to a sub-region, or an SMSA like Denver? Many approaches are possible. If one can assume that the SMSA is a reasonably accurate "replica" of the national economy, then a simple reduction of the national projections is all that would be needed. For example, Colorado has about 1% of the population of the United States. If the assumption is made that Colorado in 1970 and 1975 will reflect the occupational patterns of the United States, then a reduction of the national matrices to 1% of the total would give the desired state occupational projections, assuming continuance of the 1% proportion.

A second approach is a modification of the first. If a constant relationship exists between the local occupational patterns and the national, or if the pattern is changing in a discernible and predictable manner, then the United States matrix can be used, with the appropriate modification. For example, if the Colorado employment in manufacturing industries is far below the national, but is closing this gap by a certain amount, on the average, each year or each five years, then modification of the national matrix projections is easily done and the desired local projections can be obtained. For example, if Colorado employment in manufacturing occupies about 19% of the employment compared to 29% for the national. If the national projections indicate that the 29% is likely to remain unchanged for 1970, and if one can assume that Colorado will tend to add 1/2% per year to manufacturing (evenly taken from all other categories), then the national matrix could once again serve as the basis for derivation of local projections.

In the case that the local occupational patterns differ significantly from the national patterns, and have no discernible regular relationship to the national patterns, then different approaches must be adopted. One possibility is to disaggregate the local occupational matrix and compare each industry with the national patterns and changes in those patterns. It is likely that individual industries (such as state and local government) will bear a discernible relationship to the U. S. total for such industries, even if aggregate relationships are unclear. Many supportive industries are more closely related to population than they are to supplying industries or to markets. These are broadly the "service" industries (schools, medicine, banking, insurance, portions of the transportation industry, state and local government, portions of construction, retail and wholesale trade, and similar industries). These activities are not evenly distributed over the United States economy, but what is important is that they bear a predictable relationship to population or to a sub-region of the total economy. Banking and financial activities will be relatively more heavily concentrated in New York, Chicago, San Francisco and

Los Angeles than in Denver. But if the estimates for final demand and economic activity for Denver can be projected in 1970 and 1975, then it is feasible that the relation of finance occupations for the U.S. SMSA's (excluding New York) to total economic activity will help in estimates for the Denver finance occupations.

Still another approach to the projection of occupational patterns for the Denver SMSA is to re-do for the regional economy (in this case probably Colorado, Wyoming, and portions of northern New Mexico, eastern Utah, northern Arizona, and western portions of Kansas and Nebraska) what was done for the entire U. S. economy. For example, if input-output tables for the Denver SMSA were available for 1947 and 1958 (or whatever years were available for the national economy), then it is possible to conceive of a sub-region analysis comparable to that of the U. S. economy as a whole. Final demand projections would first be made (based on projections for "export" industries and various types of domestic sectors). The occupational projections for 1970 and 1975 could be made on the basis of productivity and occupational profile projections.

Another method, particularly adaptable to regional input-output tables, when available, is to categorize SMSA's into five or ten different types and then study only one "typical" example of each category. The results from these studies would then apply to each individual SMSA, using the proper "ideal" type as a guide. Denver would fall into that category where the SMSA fulfilled the service, government, and entrepot functions for a fairly large primary producing area. This gives the Denver economy a definite hour-glass shape -- heavy primary and tertiary employment, but relatively small secondary, manufacturing employment. Denver's manufacturing employment is concentrated in food processing (servicing agriculture), printing and other service type manufacturing, and in two fields where historical accident found two major firms prospering and expanding -- Gates Rubber (rubber products) and Schwayder Brothers (luggage which is included in leather products). Schwayder has recently announced plans for a new headquarters and plant in the Denver area, but additional expansion by Gates, or other existing manufacturers, is likely to be guided by cost considerations. Thus, the "hour-glass" category of SMSA's will probably continue to apply to Denver, which like other SMSA's in this category will still add non-service manufacturing, but probably not in large numbers. This approach is similar to the one described earlier that concentrates on the "service" industry component, but only because Denver's economic composition corresponds to that type of "ideal" SMSA. Various other types of SMSA's would require very different approaches. For example, an SMSA heavily oriented to heavy industry or steel would have an I-0 table with a middle bulge (heavy manufacturing) and would be quite different from the "service" approach. Modifications away from the ideal projections would then follow.

Another approach to SMSA occupational projections is to make a thorough locational analysis of American industry, with particular emphasis on projections. Such a study lends itself to being combined with estimates of future technological changes (products and productivity), because often these changes are closely related to locational shifts (and centralization or decentralization moves). Industry associations have great interest in such studies and often have considerable data and information. Moreover, such a study supplements all other local or regional studies and would permit taking account of foreign competition and markets, which are so important to the national I-0 projections. It amounts to an industry analysis, with emphasis on geographical distribution.

No single method of projection for the SMSA's is best. Each makes different assumptions, and those assumptions that appear to be most proper for the SMSA and the data should determine the method most likely to give good results. All methods, except perhaps the detailed I-0 tables, assume that the occupational profile of the sub-region is the same as that of the entire economy. Studies to check the validity of this assumption appear to be in order. Not every industry sector is sufficiently homogeneous, either in product mix or in locational plant mix, to assume a priori a homogeneous occupational profile for each dollar of output throughout the economy. For example, an SMSA heavily weighted with pedigree dogs will have a very different occupational profile, for each dollar of output in "livestock products," than does an SMSA heavily weighted with poultry farms or cattle spreads. But perfection is not the goal. Projections adequate for good decision guides in vocational and general education is the aim. The matrix and I-0 approach provides sufficient flexibility and plenitude to show considerable promise. Let us proceed to see what data are available and how this might affect our decisions on method.

THE DATA

The data upon which all occupational projections must presently depend are census data. There are also available in far less detail data from the Current Population Survey, the Bureau of Labor Statistics' series on employment and earnings, and data from the Bureau of Employment Security. In addition there are special industry or occupation surveys and also special area skill surveys. However, all of the occupational basic data applicable directly to SMSA analysis stem from the decennial census and with this data we will begin and end the section on data analysis.

The decennial census has traditionally included questions about the occupation of those employed. In the 1950 census occupation data were taken in detail by the enumerator. The 1960 questionnaire for detailed social and economic questions was left with the interviewee, on a 25% sample, to be filled out at leisure and mailed in. The 1960 census was evaluated by a series of studies, series ER 60, Evaluation and Research Program of the U. S. Censuses of Population and Housing (ERP). Using the PES to evaluate the 1950 census and the ERP to evaluate the 1960 census, a good understanding can be reached for the role that census data should play in occupational projections. The important thing to keep in mind is that these evaluations deal only with the major occupational breakdown on a national basis. For SMSA occupational projections, detailed occupational information on a local basis are traditionally used.

In the PES re-survey of the 1950 census, between 25,000 and 35,000 "best" respondents were interviewed by superior interviewers who were paid on an hourly basis, instead of the piece rates used in the census. "The PES information was compared with the census information on a case-by-case basis by the PES interviewer in the field, immediately following the PES interview. An explanation of any discrepancies was sought from the respondent, and appropriate changes made in the re-interview results where needed."[3/] Thus the PES classification is considered "correct," and the classification of the census is

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[3/] U. S. Bureau of the Census, The Post-Enumeration Survey: 1950; Bureau of the Census, Technical Paper No. 4, Washington, D. C., 1960, p. 1.

compared to that. Errors due to under-reporting (or over-reporting, although for the census as a whole estimates are probably under-reported by some 3½ million) or coding or machine imperfection are relatively unimportant for occupational information. The main error by far is the incorrect classification error.

Table I tells us, for example, from column (10) that the census classified 4,910,000 of those employed as professional, technical and kindred workers. Of these, 39,000 were erroneously included in the census, leaving 4,871,000. Of these, 364,000 are listed as "occupation not reported," and 11,000 as under 14 years of age, leaving 4,496,000. Of the 4,496,000 which census classified as professionals, 11,000 should have been farmers and farm managers; 95,000 should have been classified as managers; 106,000 should have been classified as clerical and kindred workers; 31,000 as sales workers; 83,000 as craftsmen, foremen, and kindred workers; 76,000 as operatives and kindred workers; 36,000 as service workers; and 13,000 as laborers. This leaves 4,045,000 classified as professionals in both PES and census. According to PES, 4,543,000 should have been so classified.

There are several ways that the various errors can be evaluated and summarized. The lower portion of Table I is the way it was done in the PES analysis. After presenting the ERC data for the 1960 census, the errors will be presented in the same form as found in the ERC analysis, and the two censuses will be compared. For the same column (10), professional, technical and kindred workers, one starts with the same total reported in census, 4,910,000. Of these, 39,000 were erroneously included in the census; 11,000 were under 14 years of age; 364,000 did not have their occupation reported in either the census or the PES, or both; 451,000 were erroneously included in class in census; 381,000 were erroneously excluded from class in census. The gross overstatement in census was 501,000; the gross understatement in census was 498,000; and the total gross errors in the census, adding the two previous totals together, was 999,000. However, since the understatements and overstatements in large part offset one another -- for the totals only -- the net deficiency as percent of census count is quite small, only -.06%. If, on the other hand, each gross error total is taken by itself, the percentage error is in the order of magnitude of 10% each. Once again returning to the PES table, however, if a percentage distribution of the major occupations is compiled for census and for PES, the largest difference is only .36%

TABLE I

PES ESTIMATES OF ERROR IN REPORTING MAJOR OCCUPATION GROUP FOR ALL PERSONS

(Thousands of persons)

PES classification	PES total	Omitted from census	Persons included in census, by census classification																		
			Total	Under 14 years old	14 years old and over																
					Total	Not empl.	Employed														
							Total	Occup. not rptd.	Occupation reported												
									Total	Prof., tech., etc.	Farmers & farm mgrs.	Mgrs., offls., etc.	Clerical workers	Sales workers	Craftsmen, etc.	Operatives, etc.	Private hsehld. workers	Service wkrs, ex hsehld.	Farm unp. fam workers	Farm lab. exc unpaid	Laborers, exc farm
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
1. Census total	...	...	150,697	38,343	112,354	56,115	56,239	732	55,507	4,910	4,309	5,018	6,895	3,927	7,783	11,140	1,408	4,286	910	1,490	3,431
2. Erroneously included in census	...	...	1,309	270	1,039	513	526	16	510	39	11	51	90	27	71	99	12	49	5	31	25
3. Properly included in census	152,788	3,400	149,388	38,073	111,315	55,602	55,713	716	54,997	4,871	4,298	4,967	6,805	3,900	7,712	11,041	1,396	4,237	905	1,459	3,406
4. Under 14 years old	38,804	725	38,079	37,772	307	236	71	...	71	11	...	...	14	10	5	10	5	5	6	5	...
5. 14 years old and over	113,984	2,675	111,309	301	111,008	55,366	55,642	716	54,926	4,860	4,298	4,967	6,791	3,890	7,707	11,031	1,391	4,232	899	1,454	3,406
6. Not employed	56,850	1,278	55,572	206	55,366	55,366	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7. Employed	57,134	1,397	55,737	95	55,642	...	55,642	716	54,926	4,860	4,298	4,967	6,791	3,890	7,707	11,031	1,391	4,232	899	1,454	3,406
8. Occupation not reported	4,204	20	4,184	...	4,184	...	4,184	408	3,776	364	175	188	288	237	470	634	223	479	104	291	323
9. Occupation reported	52,930	1,377	51,553	95	51,458	...	51,458	308	51,150	4,496	4,123	4,779	6,503	3,653	7,237	10,397	1,168	3,753	795	1,163	3,083
10. Professional, technical and kindred wkrs.	4,543	98	4,445	3	4,442	...	4,442	16	4,426	4,045	5	96	97	50	52	32	...	15	...	10	24
11. Farmers and farm managers	4,187	72	4,115	12	4,103	...	4,103	12	4,091	11	3,750	5	...	5	13	16	...	...	89	177	25
12. Mgrs., officials, & proprs., except farm.	5,143	124	5,019	3	5,016	...	5,016	95	4,921	95	32	3,888	155	261	206	147	3	81	...	8	45
13. Clerical and kindred workers	6,775	146	6,629	26	6,603	...	6,603	43	6,560	106	5	128	5,864	108	90	124	...	26	3	34	72
14. Sales workers	3,671	74	3,597	6	3,591	...	3,591	10	3,581	31	10	148	127	3,026	34	59	...	59	...	...	87
15. Craftsmen, foremen, and kindred workers	7,598	144	7,454	8	7,446	...	7,446	15	7,431	83	14	245	55	26	6,133	566	...	37	...	15	257
16. Operatives and kindred workers	10,748	261	10,487	34	10,453	...	10,453	63	10,390	76	39	154	139	119	538	8,840	18	56	5	26	380
17. Private household workers	1,293	82	1,211	...	1,211	...	1,211	14	1,197	...	...	...	10	5	...	11	1,097	43	23	8	...
18. Service workers, exc. private household	3,927	123	3,804	...	3,804	...	3,804	20	3,784	36	6	87	33	37	28	68	45	3,386	5	...	53
19. Farm laborers, unpaid family workers	784	31	753	...	753	...	753	...	753	...	63	...	...	...	5	6	...	...	588	79	12
20. Farm laborers, except unpaid and foremen.	1,095	83	1,012	3	1,009	...	1,009	3	1,006	...	123	...	...	...	...	15	5	...	64	773	26
21. Laborers, except farm and mine	3,166	139	3,027	...	3,027	...	3,027	17	3,010	13	76	28	23	16	138	513	...	50	18	33	2,102

Analysis of errors	Classification	Census or PES classification (as indicated in col. 2)																		
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
a. Census total	Census	150,697	38,343	112,354	56,115	56,239	732	55,507	4,910	4,309	5,018	6,895	3,927	7,783	11,140	1,408	4,286	910	1,490	3,431
b. Erroneously included in census	Census	1,309	270	1,039	513	526	16	510	39	11	51	90	27	71	99	12	49	5	31	25
c. Under 14 or not empl. in census, PES or both	Census	93,746	38,073	55,673	55,602	71	...	71	11	...	...	14	10	5	10	5	5	6	5	...
d. Occupation not rptd. in census, PES or both	Census	4,492	...	4,492	...	4,492	716	3,776	364	175	188	288	237	470	634	223	479	104	291	323
e. Classified by occupation in both census and PES	Census	51,150	...	51,150	...	51,150	...	51,150	4,496	4,123	4,779	6,503	3,653	7,237	10,397	1,168	3,753	795	1,163	3,083
f. Erroneously included in class in census	Census	7,658	...	7,658	...	7,658	...	7,658	451	373	891	639	627	1,104	1,557	71	367	207	390	981
g. Correctly classified in census	Both	43,492	...	43,492	...	43,492	...	43,492	4,045	3,750	3,888	5,864	3,026	6,133	8,840	1,097	3,386	588	773	2,102
h. Erroneously excluded from class in census	PES	7,658	...	7,658	...	7,658	...	7,658	381	341	1,033	696	555	1,298	1,550	100	398	165	233	908
i. Classified by occupation in both census and PES	PES	5,150	...	5,150	...	5,150	...	51,150	4,426	4,091	4,921	6,560	3,581	7,431	10,390	1,197	3,784	753	1,006	3,010
j. Occupation not rptd. in census, PES or both	PES	4,492	...	4,492	...	4,492	4,184	308	16	12	95	43	10	15	63	14	20	...	3	17
k. Under 14 or not empl. in census, PES or both	PES	93,746	38,079	55,667	55,572	95	...	95	3	12	3	26	6	8	34	...	...	...	3	...
m. Omitted from census	PES	3,400	725	2,675	1,278	1,397	20	1,377	98	72	124	146	74	144	261	82	123	31	83	139
n. PES total	PES	152,788	38,804	113,984	56,850	57,134	4,204	52,930	4,543	4,187	5,143	6,775	3,671	7,598	10,748	1,293	3,927	784	1,095	3,166
o. Occupation not rptd. in PES, rptd. in census	(line d)	...	...	...	...	...	-3,776	3,776	364	175	188	288	237	470	634	223	479	104	291	323
p. PES adjusted estimate	(n+o)	152,788	38,804	113,984	56,850	57,134	428	56,706	4,907	4,362	5,331	7,063	3,908	8,068	11,382	1,516	4,406	888	1,386	3,489
q. Net deficiency in census	(p-a)	2,091	461	1,630	735	895	-304	1,199	-3	53	313	168	-19	285	242	108	120	-22	-104	58
1. Coverage	(m-b)	2,091	455	1,636	765	871	4	867	59	61	73	56	47	73	162	70	74	26	52	114
2. Errors in identification of 14+ empl. group	(k-c)	...	6	-6	-30	24	...	24	-8	12	3	12	-4	3	24	-5	-5	-6	-2	...
3. Nonreporting in census	(j)	...	...	...	...	...	-308	308	16	12	95	43	10	15	63	14	20	...	3	17
4. Misclassification	(h-f)	...	...	...	...	...	...	...	-70	-32	142	57	-72	194	-7	29	31	-42	-157	-73
r. Gross overstatement in census	(b+c+f)	...	...	...	...	...	...	8,239	501	384	942	743	664	1,180	1,666	88	421	218	426	1,006
s. Gross understatement in census	(h+k+m+j)	...	...	...	...	...	...	9,438	498	437	1,255	911	645	1,465	1,908	196	541	196	322	1,064
t. Total gross errors in census	(r+s)	...	...	...	...	...	...	17,677	999	821	2,197	1,654	1,309	2,645	3,574	284	962	414	748	2,070
1. Coverage	(b+m)	...	...	...	...	...	...	1,887	137	83	175	236	101	215	360	94	172	36	114	164
2. Errors in identification of 14+ empl. group	(c+k)	...	...	...	...	...	...	166	14	12	3	40	16	13	44	5	5	6	8	...
3. Nonreporting in census	(j)	...	...	...	...	...	...	308	16	12	95	43	10	15	63	14	20	...	3	17
4. Misclassification	(f+h)	...	...	...	...	...	...	15,316	832	714	1,924	1,335	1,182	2,402	3,107	171	765	372	623	1,889
u. Net deficiency as percent of census count	(q/a)	1.39	1.20	1.45	1.31	1.59	-41.53	2.16	-.06	1.23	6.24	2.44	-.48	3.66	2.17	7.67	2.80	-2.42	-6.98	1.69
v. Census percentage distribution	(a)	...	...	...	...	...	...	100.00	8.85	7.76	9.04	12.42	7.07	14.02	20.07	2.54	7.72	1.64	2.68	6.18
w. PES percentage distribution	(p)	...	...	...	...	...	...	100.00	8.65	7.69	9.40	12.46	6.89	14.23	20.07	2.67	7.77	1.57	2.44	6.15
x. Difference in percentage points	(w-v)	...	...	...	...	...	...	...	-.20	-.07	.36	.04	-.18	.21	...	.13	.05	-.07	-.24	-.03

Source: The Post-Enumeration Survey: 1950, Technical Paper No. 4, Bureau of the Census, U. S. Department of Commerce, p. 35.

and it is for column (12), managers (9.04% for census and 9.40 for PES). This means that on an overall basis, most of the errors were offsetting. The important question for this study is whether these errors would be offsetting for small sub-regions and for detailed occupational groups. Although nothing has been released on this general analysis, and perhaps the PES did not have sufficient data to justify a more detailed breakdown, the census people themselves have raised questions regarding the quality of the occupation information. "Experimental evidence collected during the course of the 1950 censuses demonstrated that the variability of interpretations and performances of the enumerators could have an adverse effect on the quality of the data collected --especially on data for characteristics that are difficult to classify such as employment status and occupation."[4/]

Table II shows the same analysis for major industry group for all persons, as was discussed for major occupation. The classification errors for industry are somewhat smaller than for occupations, with total gross overstatement plus understatement running about 14,000,000, as compared to almost 18,000,000 for occupations. No analysis of the errors of cross-classification is available (by industry, by occupation). This is most unfortunate because these are the classifications needed to begin work on occupational profiles.

For the 1960 census a different approach was used to check the occupation and industry responses. First of all one should keep in mind that the census itself was conducted in a different way. The more detailed questionnaire on social and economic matters was left at 25% of the homes and mailed into the Census Bureau with a "follow-up." This procedure eliminated errors that might be introduced by the enumerators, or variations in approaches of the enumerators. The portion of the ERP that concerns this study is the Employer Record Check (ERC). "This study was designed to obtain information on the comparability of census reports made by respondents concerning their occupation and industry with corresponding information obtained from their employers. Occupations as reported by employees were matched with occupations as reported by their employers for a sample of employees reported in the census. In addition, the classification of the industry of these employers was identified in records

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[4/] U. S. Bureau of the Census, Procedural Report on the 1960 Censuses of Population and Housing, Working Paper No. 16, Washington, D. C., p. 8.

TABLE II

PES ESTIMATES OF ERROR IN REPORTING MAJOR INDUSTRY GROUP FOR ALL PERSONS

(Thousands of persons)

PES classification	PES Total	Omitted from census	Persons included in census, by census classification																					
			Total	Under 14 years old	14 years old and over																			
					Total	Not empl.	Employed																	
							Total	Ind. not rptd.	Industry reported															
									Total	Agric.	Min.	Const.	Mfg.-dur.	Mfg.-nondur	Mfg.-n. s.	Trans.	Whol. Trade	Ret. Trade	Fin., etc.	Bus. & rep.	Per. serv.	Ent., rec.	Prof. Serv.	Pub. adm.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
1. Census total	...	...	150,697	38,343	112,354	56,115	56,239	840	55,399	7,005	929	3,440	7,757	6,697	122	4,368	1,976	8,572	1,916	1,411	3,488	554	4,675	2,489
2. Erroneously included in census	...	...	1,309	270	1,039	513	526	24	502	48	...	49	44	60	...	43	46	41	13	11	12	13	49	73
3. Properly included in census	152,788	3,400	149,388	38,073	111,315	55,602	55,713	816	54,897	6,957	929	3,391	7,713	6,637	122	4,325	1,930	8,531	1,903	1,400	3,476	541	4,626	2,416
4. Under 14 years old	38,804	725	38,079	37,772	307	236	71	...	71	11	...	...	5	5	...	5	5	5	...	...	15	11	...	9
5. 14 years old and over	113,984	2,675	111,309	301	111,008	55,366	55,642	816	54,826	6,946	929	3,391	7,708	6,632	122	4,320	1,925	8,526	1,903	1,400	3,461	530	4,626	2,407
6. Not employed	56,850	1,278	55,572	206	55,366	55,366	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7. Employed	57,134	1,397	55,737	95	55,642	...	55,642	816	54,826	6,946	929	3,391	7,708	6,632	122	4,320	1,925	8,526	1,903	1,400	3,461	530	4,626	2,407
8. Industry not reported	4,272	24	4,248	...	4,248	...	4,248	485	3,763	607	57	387	369	283	14	247	122	669	71	71	361	38	362	105
9. Industry reported	52,862	1,373	51,489	95	51,394	...	51,394	331	51,063	6,339	872	3,004	7,339	6,349	108	4,073	1,803	7,857	1,832	1,329	3,100	492	4,264	2,302
10. Agriculture, forestry, and fisheries	6,346	201	6,145	14	6,131	...	6,131	20	6,111	5,945	6	21	30	14	...	8	20	19	...	...	29	...	19	...
11. Mining	875	19	856	5	851	...	851	...	851	16	782	8	21	16	...	2	3	3	...	...	...	...	...	...
12. Construction	3,214	98	3,116	...	3,116	...	3,116	19	3,097	72	23	2,648	92	18	...	32	5	64	23	11	3	...	24	32
13. Manufacturing--durable goods	7,657	180	7,477	7	7,470	...	7,470	23	7,447	33	9	88	6,627	148	30	99	166	128	8	38	20	10	19	24
14. Manufacturing--nondurable goods	6,471	125	6,346	5	6,341	...	6,341	48	6,293	21	9	18	127	5,616	25	47	152	211	5	10	19	...	15	18
15. Manufacturing-not specified	57	...	57	...	57	...	57	...	57	...	...	...	...	...	43	...	...	...	...	...	...	...	14	...
16. Transport., commun., & other public util.	4,310	93	4,217	...	4,217	...	4,217	56	4,161	43	13	37	74	41	...	3,778	74	19	30	10	2	5	10	25
17. Wholesale trade	1,892	52	1,840	21	1,819	...	1,819	18	1,801	44	...	32	95	211	...	15	1,028	288	9	48	3	14	14	...
18. Retail trade	8,307	219	8,088	30	8,058	...	8,058	23	8,035	24	18	66	144	214	5	38	329	6,828	21	206	76	10	43	13
19. Finance, insurance, and real estate	1,889	44	1,845	...	1,845	...	1,845	5	1,840	10	12	23	9	8	...	...	...	...	1,686	16	47	...	14	15
20. Business and repair services	1,315	21	1,294	...	1,294	...	1,294	19	1,275	5	...	24	64	23	...	21	10	142	...	941	...	14	5	26
21. Personal services	3,305	138	3,167	5	3,162	...	3,162	21	3,141	73	...	...	3	10	5	5	9	86	14	10	2,883	...	43	...
22. Entertainment and recreation services	492	24	468	...	468	...	468	21	447	...	...	...	...	5	...	...	...	13	...	5	5	414	...	5
23. Professional and related services	4,435	110	4,325	3	4,322	...	4,322	58	4,264	42	...	5	27	15	...	5	5	37	23	19	13	20	3,987	66
24. Public administration	2,297	49	2,248	5	2,243	...	2,243	...	2,243	11	...	34	26	10	...	23	2	19	13	15	...	5	57	2,028
Analysis of errors		Classification	Census or PES classification (as indicated in col. 2)																					
		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
a. Census total		Census	150,697	38,343	112,354	56,115	56,239	840	55,399	7,005	929	3,440	7,757	6,697	122	4,368	1,976	8,572	1,916	1,411	3,488	554	4,675	2,489
b. Erroneously included in census		Census	1,309	270	1,039	513	526	24	502	48	...	49	44	60	...	43	46	41	13	11	12	13	49	73
c. Under 14 or not empl. in census, PES, or both		Census	93,746	38,073	55,673	55,602	71	...	71	11	...	...	5	5	...	5	5	5	...	...	15	11	...	9
d. Industry not reported in census, PES, or both		Census	4,579	...	4,579	...	4,579	816	3,763	607	57	387	369	283	14	247	122	669	71	71	361	38	362	105
e. Classified by industry in both census and PES		Census	51,063	...	51,063	...	51,063	...	51,063	6,339	872	3,004	7,339	6,349	108	4,073	1,803	7,857	1,832	1,329	3,100	492	4,264	2,302
f. Erroneously included in class in census		Census	5,829	...	5,829	...	5,829	...	5,829	394	90	356	712	733	65	295	775	1,029	146	388	217	78	277	274
g. Correctly classified in census		Both	45,234	...	45,234	...	45,234	...	45,234	5,945	782	2,648	6,627	5,616	43	3,778	1,028	6,828	1,686	941	2,883	414	3,987	2,028
h. Erroneously excluded from class in census		PES	5,829	...	5,829	...	5,829	...	5,829	166	69	449	820	677	14	383	773	1,207	154	334	258	33	277	215
i. Classified by industry in both census and PES		PES	51,063	...	51,063	...	51,063	...	51,063	6,111	851	3,097	7,447	6,293	57	4,161	1,801	8,035	1,840	1,275	3,141	447	4,264	2,243
j. Industry not reported in census, PES, or both		PES	4,579	...	4,579	...	4,579	4,248	331	20	...	19	23	48	...	56	18	23	5	19	21	21	58	...
k. Under 14 or not empl. in census, PES, or both		PES	93,746	38,079	55,667	55,572	95	...	95	14	5	...	7	5	...	...	21	30	...	...	5	...	3	5
m. Omitted from census		PES	3,400	725	2,675	1,278	1,397	24	1,373	201	19	98	180	125	...	93	52	219	44	21	138	24	110	49
n. PES total		PES	152,788	38,804	113,984	56,850	57,134	4,272	52,862	6,346	875	3,214	7,657	6,471	57	4,310	1,892	8,307	1,889	1,315	3,305	492	4,435	2,297
o. Industry not reported in PES, reported in census		(line d)	...	...	...	...	...	-3,763	3,763	607	57	387	369	283	14	247	122	669	71	71	361	38	362	105
p. PES adjusted estimate		(n+o)	152,788	38,804	113,984	56,850	57,134	509	56,625	6,953	932	3,601	8,026	6,754	71	4,557	2,014	8,976	1,960	1,386	3,666	530	4,797	2,402
q. Net deficiency in census		(p-a)	2,091	461	1,630	735	895	-331	1,226	-52	3	161	269	57	-51	189	38	404	44	-25	178	-24	122	-87
1. Coverage		(m-b)	2,091	455	1,636	765	871	...	871	153	19	49	136	65	...	50	6	178	31	10	126	11	61	-24
2. Errors in identification of 14+ empl. group		(k-c)	...	6	-6	-30	24	...	24	3	5	...	2	...	...	-5	16	25	...	...	-10	-11	3	-4
3. Nonreporting in census		(j)	...	...	...	...	...	-331	331	20	...	19	23	48	...	56	18	23	5	19	21	21	58	...
4. Misclassification		(h-f)	...	...	...	...	...	...	...	-228	-21	93	108	-56	-51	88	-2	178	8	-54	41	45	...	-59
r. Gross overstatement in census		(b+c+f)	...	...	...	...	...	...	6,402	453	90	405	761	798	65	343	826	1,075	159	399	244	102	326	356
s. Gross understatement in census		(h+j+k+m)	...	...	...	...	...	...	7,628	401	93	566	1,030	855	14	532	864	1,479	203	374	422	78	448	269
t. Total gross errors in census		(r+s)	...	...	...	...	...	...	14,030	854	183	971	1,791	1,653	79	875	1,690	2,554	362	773	666	180	774	625
1. Coverage		(b+m)	...	...	...	...	...	...	1,875	249	19	147	224	185	...	136	98	260	57	32	150	37	159	122
2. Errors in identification of 14+ empl. group		(c+k)	...	...	...	...	...	...	166	25	5	...	12	10	...	5	26	35	...	...	20	11	3	14
3. Nonreporting in census		(j)	...	...	...	...	...	...	331	20	...	19	23	48	...	56	18	23	5	19	21	21	58	...
4. Misclassification in census		(f+h)	...	...	...	...	...	...	11,658	560	159	805	1,532	1,410	79	678	1,548	2,236	300	722	475	111	554	489
u. Net deficiency as percent of census count		(q/a)	1.39	1.20	1.45	1.31	1.59	-39.40	2.21	-.74	.32	4.68	3.47	.85	-41.80	4.33	1.92	4.71	2.30	-1.77	5.10	-4.33	2.61	-3.50
v. Census percentage distribution		(a)	...	...	...	...	...	...	100.00	12.64	1.68	6.21	14.00	12.09	.22	7.88	3.57	15.47	3.46	2.55	6.30	1.00	8.44	4.49
w. PES percentage distribution		(p)	...	...	...	...	...	...	100.00	12.28	1.65	6.36	14.17	11.93	.13	8.05	3.56	15.85	3.46	2.45	6.47	.94	8.47	4.26
x. Difference in percentage points		(w-v)	...	...	...	...	...	...	...	-.36	-.03	.15	.17	-.16	-.09	.17	-.01	.38	...	-.10	.17	-.06	.03	-.23

Source: The Post-Enumeration Survey: 1950, Technical Paper No. 4, Bureau of the Census, U. S. Department of Commerce, p. 37.

of the Bureau of Old Age and Survivors Insurance, and comparisons were made of these classifications with industry as reported in the population census."[5/]

Since the city of Denver was included in the two-stage area procedure, as were most of the SMSA's, let us go over the "professional" category for the two-stage areas (Column 4). Only 3,579,000 were classified as professionals by the employer record check (ERC). Of these, 17,000 were incorrectly reported by census as managers; 150,000 as clerical; 36,000 as sales workers; 127,000 as craftsmen; 38,000 as operatives; 21,000 as service workers; and 21,000 as laborers. Therefore, although the number of professionals reported is considerably less than that reported in 1950, the order of magnitude of the classification errors, as estimated by the employer check, was as great. Only 3,169,000 professionals were classified by both census (out of a total of 3,985,000) and ERC (out of a total of 3,579,000). In 1950, the number classified by both were 4,045,000, out of a total of 4,910,000 for census, and out of a total of 4,543,000 for PES. In other words, in both the 1950 and the 1960 censuses about 80% of the professionals had a common classification in census and the PES and ERC, as a percent of census. However, it must be stressed that the 1960 ERC check was an employer survey, instead of a household survey (see Table III).

The industry reporting of the 1960 census appears to be a considerable improvement over the 1950 census. Table IV shows the major industry groups in census and ERC. Except for construction, wholesale trade, and business and repair services, the matches are quite close. Somewhat less reassuring for this study is Table V, where the place of work is compared by ERC and 1960 census. Of 28,539,000 employees in the two-stage areas reporting a place of work, only 23,996,000 reported the same place of work as found in the ERC. If an error of approximately 15% in the place of work designation must be added to the errors in industry and occupations,[5a/] then the outlook for the use of census data for an SMSA detailed occupational

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[5/] U. S. Bureau of the Census, Evaluation and Research Program of the U. S. Censuses of Population and Housing, 1960: Background, Procedures, and Forms, Series ER60, No. 1, Washington, D. C., 1963, p. 8.

[5a/] Although the place of work error is not necessarily additive to the errors in industry and occupation, for SMSA occupation projections the additional place of work error must be taken into account. In lieu of more information, a simple additive relationship may be implied--but only as a first approximation.

TABLE III

MAJOR OCCUPATION GROUP ACCORDING TO PRIMARY JOB TITLE REPORTED BY EMPLOYER AND 1960 CENSUS; FOR CONTERMINOUS UNITED STATES, BY TYPE OF ENUMERATION AREA

(Thousands of persons)

Employer classification and area	Census classification										
			Occupation reported								
	Total employed[1] (1)	Occupation not reported (2)	Total (3)	Professional, technical, and kindred workers (4)	Managers, officials, and proprietors except farm (5)	Clerical and kindred workers (6)	Sales workers (7)	Craftsmen, foremen, and kindred workers (8)	Operatives, and kindred workers (9)	Service workers except private household (10)	Laborers except farm and mine (11)
UNITED STATES											
Total employed	48,499	420	48,079	5,672	2,673	7,693	4,252	8,619	11,756	4,825	2,589
Occupation unknown	10,374	66	10,308	967	553	1,198	905	2,106	2,570	1,068	961
Employer form not returned	256	-	256	-	-	42	44	73	39	58	-
Employer form returned	10,118	66	10,052	967	553	1,156	861	2,033	2,531	990	961
Wrong address, out of business, insufficient address	3,888	45	3,843	267	165	378	465	813	665	600	490
Retired	43	-	43	20	23	-	-	-	-	-	-
Not with firm or deceased	5,628	21	5,607	656	365	753	360	1,078	1,637	326	432
Occupation not reported	559	-	559	24	-	25	36	142	229	64	39
Occupation reported	38,125	354	37,771	4,705	2,120	6,495	3,347	6,513	9,186	3,777	1,628
Professional, technical, and kindred workers	4,283	-	4,283	3,805	17	150	36	195	38	21	21
Managers, officials, and proprietors, except farm	2,853	119	2,734	107	1,569	204	267	262	191	115	19
Clerical and kindred workers	6,624	21	6,603	270	287	5,511	139	84	71	158	83
Sales workers	3,043	25	3,018	19	122	82	2,689	38	47	21	-
Craftsmen, foremen, and kindred workers	6,165	58	6,107	148	61	173	37	4,926	547	21	124
Operatives and kindred workers	9,037	106	8,931	71	64	261	93	676	7,483	41	242
Service workers, except private household	3,973	-	3,973	262	-	46	-	82	153	3,344	86
Laborers, except farm and mine	2,147	25	2,122	23	-	68	86	180	656	56	1,053
SINGLE-STAGE AREAS											
Total employed	7,847	66	7,781	955	198	479	718	1,318	2,421	716	976
Occupation unknown	2,160	-	2,160	235	132	130	158	357	517	148	483
Employer form not returned	-	-	-	-	-	-	-	-	-	-	-
Employer form returned	2,160	-	2,160	235	132	130	158	357	517	148	483
Wrong address, out of business, insufficient address	956	-	956	-	66	-	158	158	152	148	274
Retired	-	-	-	-	-	-	-	-	-	-	-
Not with firm or deceased	990	-	990	235	66	130	-	133	217	-	209
Occupation not reported	214	-	214	-	-	-	-	66	148	-	-
Occupation reported	5,687	66	5,621	720	66	349	560	961	1,904	568	493
Professional, technical, and kindred workers	704	-	704	636	-	-	-	68	-	-	-
Managers, officials, and proprietors, except farm	200	66	134	-	66	-	-	68	-	-	-
Clerical and kindred workers	433	-	433	-	-	275	-	-	-	158	-
Sales workers	560	-	560	-	-	-	560	-	-	-	-
Craftsmen, foremen, and kindred workers	1,035	-	1,035	-	-	-	-	757	278	-	-
Operatives and kindred workers	1,411	-	1,411	-	-	74	-	68	1,203	-	66
Service workers, except private household	634	-	634	84	-	-	-	-	74	410	66
Laborers, except farm and mine	710	-	710	-	-	-	-	-	349	-	361
TWO-STAGE AREAS											
Total employed	40,652	354	40,298	4,717	2,475	7,214	3,534	7,301	9,335	4,109	1,613
Occupation unknown	8,214	66	8,148	732	421	1,068	747	1,749	2,053	900	478
Employer form not returned	256	-	256	-	-	42	44	73	39	58	-
Employer form returned	7,958	66	7,892	732	421	1,026	703	1,676	2,014	842	478
Wrong address, out of business, insufficient address	2,932	45	2,887	267	99	378	307	655	513	452	216
Retired	43	-	43	20	23	-	-	-	-	-	-
Not with firm or deceased	4,638	21	4,617	421	299	623	360	945	1,420	326	223
Occupation not reported	345	-	345	24	-	25	36	76	81	64	39
Occupation reported	32,438	288	32,150	3,985	2,054	6,146	2,787	5,552	7,282	3,209	1,135
Professional, technical, and kindred workers	3,579	-	3,579	3,169	17	150	36	127	38	21	21
Managers, officials, and proprietors, except farm	2,653	53	2,600	107	1,503	204	267	194	191	115	19
Clerical and kindred workers	6,191	21	6,170	270	287	5,236	139	84	71	-	83
Sales workers	2,483	25	2,458	19	122	82	2,129	38	47	21	-
Craftsmen, foremen, and kindred workers	5,130	58	5,072	148	61	173	37	4,239	269	21	124
Operatives and kindred workers	7,626	106	7,520	71	64	187	93	608	6,280	41	176
Service workers, except private household	3,339	-	3,339	178	-	46	-	82	79	2,934	20
Laborers, except farm and mine	1,437	25	1,412	23	-	68	86	180	307	56	692

- Represents zero

[1] Not equal to total employed in 1960 Census due to exclusion of certain groups. See text for list of exclusions.

Source: The Employer Record Check, Series ER 60, No. 6, Bureau of the Census, U. S. Department of Commerce, p. 9.

TABLE IV

MAJOR INDUSTRY GROUP ACCORDING TO SOCIAL SECURITY ADMINISTRATION AND 1960 CENSUS; FOR CONTERMINOUS UNITED STATES, BY TYPE OF ENUMERATION AREA

(Thousands of persons. Social Security classification is on basis of SIC. Census classification is modification of SIC)

Social security administration classification and area	Census classification															
	Total employed with industry reported[1] (1)	Agriculture, forestry, and fisheries (2)	Mining (3)	Construction (4)	Manufacturing-durable goods (5)	Manufacturing-nondurable goods (6)	Manufacturing-not specified (7)	Transportation, communication, other public utilities (8)	Wholesale trade (9)	Retail trade (10)	Finance, insurance, and real estate (11)	Business and repair services (12)	Personal services (13)	Entertainment and recreation services (14)	Professional and related services (15)	Public administration (16)
UNITED STATES																
Total employed	48,499	213	402	2,611	10,133	8,636	87	3,697	1,663	7,807	2,231	1,009	1,375	414	5,485	2,736
Industry not coded	4,576	66	66	534	716	618	66	154	149	1,061	106	226	330	64	375	45
Employer form not returned	256	-	-	17	19	77	-	-	-	64	39	-	40	-	-	-
Employer form returned	4,320	66	66	517	697	541	66	154	149	997	67	226	290	64	375	45
Wrong address, out of business, insufficient address	3,888	66	-	493	477	479	66	154	149	976	67	208	290	43	375	45
Not enough information to code	432	-	66	24	220	62	-	-	-	21	-	18	-	21	-	-
Industry coded	43,923	147	336	2,077	9,417	8,018	21	3,543	1,514	6,746	2,125	783	1,045	350	5,110	2,691
Agriculture, forestry, and fisheries	205	41	-	42	-	-	-	-	17	105	-	-	-	-	-	-
Mining	270	-	270	-	-	-	-	-	-	-	-	-	-	-	-	-
Construction	1,836	-	66	1,388	100	89	21	66	24	40	-	42	-	-	-	-
Manufacturing-durable goods	8,629	-	-	76	8,050	320	-	-	94	25	27	17	-	-	20	-
Manufacturing-nondurable goods	7,084	-	-	22	216	6,591	-	-	126	86	-	43	-	-	-	-
Transportation, communication, other public utilities	3,213	-	-	20	25	19	-	3,064	64	-	-	-	-	-	21	-
Wholesale trade	2,669	68	-	21	462	634	-	-	1,045	396	-	22	-	-	21	-
Retail trade	6,780	17	-	95	275	210	-	84	106	5,813	-	50	64	-	45	21
Finance, insurance, and real estate	2,383	-	-	84	40	42	-	19	38	22	2,078	-	-	-	60	-
Business and repair services	794	-	-	24	62	55	-	-	-	93	20	494	-	-	21	25
Personal services	1,103	-	-	-	27	19	-	-	-	41	-	27	963	-	26	-
Entertainment and recreation services	311	-	-	-	34	-	-	-	-	-	-	-	-	256	-	21
Professional and related services	5,382	-	-	19	65	-	-	231	-	100	-	66	18	28	4,742	113
Public administration	3,264	21	-	286	61	39	-	79	-	25	-	22	-	66	154	2,511
SINGLE-STAGE AREAS																
Total employed	7,847	66	132	494	1,117	1,562	-	921	214	1,379	64	66	328	-	1,094	410
Industry not coded	1,021	66	66	74	68	168	-	84	-	299	-	-	132	-	64	-
Employer form not returned	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Employer form returned	1,021	66	66	74	68	168	-	84	-	299	-	-	132	-	64	-
Wrong address, out of business, insufficient address	955	66	-	74	68	168	-	84	-	299	-	-	132	-	64	-
Not enough information to code	66	-	66	-	-	-	-	-	-	-	-	-	-	-	-	-
Industry coded	6,826	-	66	420	1,049	1,394	-	837	214	1,080	64	66	196	-	1,030	410
Agriculture, forestry, and fisheries	84	-	-	-	-	-	-	-	-	84	-	-	-	-	-	-
Mining	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Construction	480	-	66	280	-	68	-	66	-	-	-	-	-	-	-	-
Manufacturing-durable goods	1,178	-	-	-	981	197	-	-	-	-	-	-	-	-	-	-
Manufacturing-nondurable goods	1,149	-	-	-	-	1,065	-	-	84	-	-	-	-	-	-	-
Transportation, communication, other public utilities	667	-	-	-	-	-	-	603	64	-	-	-	-	-	-	-
Wholesale trade	265	-	-	-	68	64	-	-	66	67	-	-	-	-	-	-
Retail trade	1,151	-	-	74	-	-	-	84	-	929	-	-	64	-	-	-
Finance, insurance, and real estate	130	-	-	66	-	-	-	-	-	-	64	-	-	-	-	-
Business and repair services	66	-	-	-	-	-	-	-	-	-	-	66	-	-	-	-
Personal services	132	-	-	-	-	-	-	-	-	-	-	-	132	-	-	-
Entertainment and recreation services	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Professional and related services	982	-	-	-	-	-	-	84	-	-	-	-	-	-	898	-
Public administration	542	-	-	-	-	-	-	-	-	-	-	-	-	-	132	410
TWO-STAGE AREAS																
Total employed	40,652	147	270	2,117	9,016	7,074	87	2,776	1,449	6,428	2,167	943	1,047	414	4,391	2,326
Industry not coded	3,555	-	-	460	648	450	66	70	149	762	106	226	198	64	311	45
Employer form[1] not returned	256	-	-	17	19	77	-	-	-	64	39	-	40	-	-	-
Employer form[1] returned	3,299	-	-	443	629	373	66	70	149	698	67	226	158	64	311	45
Wrong address, out of business, insufficient address	2,933	-	-	419	409	311	66	70	149	677	67	208	158	43	311	45
Not enough information to code	366	-	-	24	220	62	-	-	-	21	-	18	-	21	-	-
Industry coded	37,097	147	270	1,657	8,368	6,624	21	2,706	1,300	5,666	2,061	717	849	350	4,080	2,281
Agriculture, forestry, and fisheries	121	41	-	42	-	-	-	-	17	21	-	-	-	-	-	-
Mining	270	-	270	-	-	-	-	-	-	-	-	-	-	-	-	-
Construction	1,356	-	-	1,108	100	21	21	-	24	40	-	42	-	-	-	-
Manufacturing-durable goods	7,451	-	-	76	7,069	123	-	-	94	25	27	17	-	-	20	-
Manufacturing-nondurable goods	5,935	-	-	22	216	5,526	-	-	42	86	-	43	-	-	-	-
Transportation, communication, other public utilities	2,546	-	-	20	25	19	-	2,461	-	-	-	-	-	-	21	-
Wholesale trade	2,404	68	-	21	394	570	-	-	979	329	-	22	-	-	21	-
Retail trade	5,629	17	-	21	275	210	-	-	106	4,884	-	50	-	-	45	21
Finance, insurance, and real estate	2,253	-	-	18	40	42	-	19	38	22	2,014	-	-	-	60	-
Business and repair services	728	-	-	24	62	55	-	-	-	93	20	428	-	-	21	25
Personal services	971	-	-	-	27	19	-	-	-	41	-	27	831	-	26	-
Entertainment and recreation services	311	-	-	-	34	-	-	-	-	-	-	-	-	256	-	21
Professional and related services	4,400	-	-	19	65	-	-	147	-	100	-	66	18	28	3,844	11
Public administration	2,722	21	-	286	61	39	-	79	-	25	-	22	-	66	22	2,10

-Represents zero.

[1] Not equal to total employed in 1960 census due to exclusion of certain groups. See text for list of exclusions.

Source: The Employer Record Check, Series ER60, No. 6, Bureau of the Census, U. S. Department of Commerce, p. 12.

TABLE V

PLACE OF WORK ACCORDING TO EMPLOYER AND 1960 CENSUS; FOR CONTERMINOUS UNITED STATES

(Thousands of persons)

Place of work	Total conterminous United States	Single-stage Census areas	Two-stage Census areas
Total employed[1]	48,499	7,847	40,652
Place of work reported in Census	46,717	7,623	39,094
Place of work reported in ERC	34,078	5,099	28,979
Place of work reported in both Census and ERC	33,638	5,099	28,539
Same place of work reported	28,681	4,685	23,996
Different place of work reported	4,957	414	4,543
Different county or city in same state	4,643	348	4,295
Different state	314	66	248

[1] Not equal to total employed in 1960 Census due to exclusion of certain groups. See text for list of exclusions.

Source: The Employer Record Check, Series ER60, No. 6, Bureau of the Census, U. S. Department of Commerce, p. 13.

analysis by industry is indeed bleak. The designation for "place of work refers to the geographic location in which persons at work carry out their job activities. In the ERC study, the employer was asked to give the location at which the employee reported to work, in terms of (a) city or county, and (b) State. If the employee was assigned to several locations, the place he worked most of the time was reported."[6]

Table VI shows the analysis of variance and bias for the ERC. The most readily understood column is column 6, which indicates the percent success of the census classification, using the ERC as a guide. Or, put in another way, assuming ERC is truly correct, then column 6 tells us the percent of the census classification that is correct. Table VII compares the results of column 6 for 1960 (ERC) with those calculated from the PES study of the 1950 census. In general it shows that there was not a great improvement in the results of the 1960 census, and in two categories a possible significant deterioration; however, it must be stressed that the PES was a re-survey of households and the ERC was an employer survey.

The conclusion one must make from the review of the national data available from census in the occupation and industry fields is that these data are not too promising for use in job projections for SMSA's. Unfortunately, the PES and the ERC are not available on an SMSA basis, but if national estimates are any guide, the SMSA results would not be optimistic. If one were seriously thinking about use of the census data on an SMSA basis, it would certainly be important as a first step to explore with the Bureau of Census the possibility of running special sections of the PES and ERC applicable to the specific SMSA's involved. The samples would get very thin for many cross-classifications, but a preliminary exploration would be important. However, the inescapable conclusion seems to be that occupational information should be gathered from employers, and the sooner such a program is inaugurated, the sooner will we have reliable information on which to rationalize the labor market. Maurice Gershenson, Chief, Department of Industrial Relations, State of California, recently testified to this effect before the Joint Economic Committee.

"Our occupational statistics are entirely inadequate. The need for detailed current statistics of employment by occupation was pointed up by the Gordon committee report, 'Measuring Employment and Unemployment,' (pp. 202-

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[6] Ibid., p. 3.

TABLE VI

1960 EMPLOYER RECORD CHECK INDEXES OF RESPONSE VARIANCE AND BIAS; FOR CONTERMINOUS UNITED STATES, BY TYPE OF ENUMERATION AREA

[Figures in columns 2-5 represent indexes times 100]

Employer record check classification	Conterminous United States						Single-stage areas[1]						Two-stage areas[1]					
	Number of persons[2] (thous.) (1)	Gross difference rate (2)	Index of inconsistency (3)	Net difference rate (4)	Index of net shift relative to ERC (5)	Percent in ERC classification identically reported (6)	Number of persons[2] (thous.) (1)	Gross difference rate (2)	Index of inconsistency (3)	Net difference rate (4)	Index of net shift relative to ERC (5)	Percent in ERC classification identically reported (6)	Number of persons[2] (thous.) (1)	Gross difference rate (2)	Index of inconsistency (3)	Net difference rate (4)	Index of net shift relative to ERC (5)	Percent in ERC classification identically reported (6)
Occupation																		
Primary job title (table 1)																		
Professional, technical and kindred workers	4,283	3.64	17.38	1.11	9.80	88.83	704	2.68	12.18	0.29	2.32	90.39	3,579	3.80	18.35	1.25	11.27	88.53
Managers, officials, and proprietors, except farm	2,734	4.54	37.81	-1.62	-22.43	57.40	134	1.20	34.60	-1.20	-50.65	49.34	2,600	5.12	38.21	-1.69	-20.38	57.81
Clerical and kindred workers	6,603	5.48	19.17	-0.28	-1.64	83.45	433	4.12	31.90	-1.49	-19.38	63.51	6,170	5.72	18.52	-0.07	-0.39	84.85
Sales workers	3,018	2.60	16.94	0.87	10.90	89.09	560	0.00	0.00	0.00	0.00	100.00	2,458	3.06	20.50	1.02	13.39	86.61
Craftsmen, foremen, and kindred workers	6,107	6.94	24.99	1.07	6.62	81.80	1,035	8.54	29.32	-1.34	-7.30	73.11	5,072	6.66	24.20	1.49	9.47	83.58
Operatives and kindred workers	8,931	8.34	22.88	0.67	2.87	83.79	1,411	16.16	39.24	8.79	35.02	85.30	7,520	6.96	19.67	-0.73	-3.16	83.51
Service workers, except private household	3,973	2.80	15.27	-0.51	-4.91	84.17	634	6.78	35.56	-1.17	-10.38	64.70	3,339	2.10	11.57	-0.40	-3.87	87.86
Laborers, except farm and mine	2,122	4.34	46.17	-1.30	-23.26	49.62	710	8.54	44.96	-3.87	-30.65	50.81	1,412	3.60	47.57	-0.85	-19.53	49.02
Primary job description (table 2)																		
Professional, technical, and kindred workers	4,415	3.60	17.00	0.76	6.53	87.83	704	2.68	12.18	0.29	2.32	90.39	3,711	3.76	17.88	0.84	7.33	87.34
Managers, officials, and proprietors, except farm	2,451	3.90	34.44	-0.87	-13.47	63.09	66	0.00	0.00	0.00	0.00	100.00	2,385	4.58	35.79	-1.02	-13.84	62.07
Clerical and kindred workers	6,576	5.32	18.59	-0.21	-1.23	84.10	433	4.12	31.90	-1.49	-19.38	63.51	6,143	5.52	17.88	0.00	0.04	85.55
Sales workers	2,950	2.32	15.30	1.05	13.46	91.77	560	0.00	0.00	0.00	0.00	100.00	2,390	2.74	18.55	1.23	16.62	89.84
Craftsmen, foremen, and kindred workers	6,081	7.42	26.77	1.14	7.10	80.45	1,095	9.84	32.99	-2.40	-12.33	68.55	4,986	7.00	25.61	1.76	11.36	83.06
Operatives and kindred workers	9,141	8.16	22.23	0.11	0.49	83.36	1,419	16.30	39.53	8.64	34.25	84.81	7,722	6.74	18.86	-1.37	-5.70	83.09
Service workers, except private household	4,021	2.66	14.45	-0.64	-6.03	84.41	634	6.78	35.56	-1.17	-10.38	64.70	3,387	1.94	10.62	-0.54	-5.21	88.10
Laborers, except farm and mine	2,136	4.18	44.34	-1.34	-23.79	51.01	710	8.54	44.96	-3.87	-30.65	50.81	1,426	3.42	44.88	-0.90	-20.36	51.12
Composite report (table 3)																		
Professional, technical, and kindred workers	4,321	3.36	15.97	1.01	8.83	89.73	704	2.68	12.18	0.29	2.32	90.39	3,617	3.46	16.68	1.13	10.10	89.60
Managers, officials, and proprietors, except farm	2,521	3.72	32.35	-1.05	-15.88	64.11	66	0.00	0.00	0.00	0.00	100.00	2,455	4.38	33.61	-1.24	-15.30	63.15
Clerical and kindred workers	6,652	4.96	17.27	-0.41	-2.38	84.71	433	4.12	31.90	-1.49	-19.38	63.51	6,219	5.10	16.45	-0.23	-1.19	86.18
Sales workers	2,986	2.24	14.60	0.95	12.10	91.86	560	0.00	0.00	0.00	0.00	100.00	2,426	2.62	17.68	1.12	14.89	89.99
Craftsmen, foremen, and kindred workers	6,250	5.96	21.27	0.69	4.19	84.04	1,170	6.14	20.08	-3.74	-18.00	76.21	5,080	5.94	21.53	1.47	9.30	85.85
Operatives and kindred workers	8,996	6.90	18.91	0.50	2.13	86.54	1,344	14.96	36.87	9.99	41.82	89.99	7,652	5.50	15.44	-1.15	-4.33	86.01
Service workers, except private household	3,983	2.56	13.97	-0.54	-5.14	85.21	634	6.78	35.56	-1.17	-10.38	64.70	3,349	1.82	10.04	-0.43	-4.15	89.09
Laborers, except farm and mine	2,062	3.86	41.68	-1.14	-21.03	54.02	710	8.54	44.96	-3.87	-30.65	50.81	1,352	3.04	41.03	-0.67	-15.97	55.72
Industry (table 4)																		
Agriculture, forestry, and fisheries	205	0.60	76.80	-0.12	-27.70	20.25	84	1.22	*101.24	-1.22	-100.00	0.00	121	0.50	69.43	0.07	22.26	34.25
Mining	270	0.14	10.95	0.14	24.41	100.00	0	0.96	*100.97	0.96	0.00	100.00	270	0.00	0.00	0.00	0.00	100.00
Construction	1,836	2.58	30.41	0.55	13.18	75.62	480	4.96	40.37	-0.87	-12.39	58.43	1,356	2.14	27.60	0.91	22.23	81.70
Manufacturing-durable goods	8,629	4.42	13.58	1.79	9.12	93.28	1,178	3.86	14.18	-1.88	-10.95	83.31	7,451	4.52	13.53	2.47	12.30	94.86
Manufacturing-nondurable goods	7,084	4.36	15.36	2.12	13.18	93.04	1,149	6.04	19.98	3.58	21.29	92.69	5,935	4.06	14.45	1.85	11.61	93.10
Transportation, communication, other public utilities	3,213	1.42	10.06	0.74	10.22	95.34	667	4.36	22.31	2.47	25.35	90.33	2,546	0.88	6.75	0.42	6.26	96.65
Wholesale trade	2,669	4.76	52.74	-2.62	-43.26	39.14	265	5.08	75.23	-0.75	-19.29	24.79	2,404	4.70	49.83	-2.97	-45.91	40.73
Retail trade	6,780	4.32	16.60	-0.07	0.49	85.73	1,151	5.46	20.03	-1.03	-6.15	80.68	5,629	4.10	15.93	0.09	0.65	86.77
Finance, insurance, and real estate	2,383	0.80	8.22	-0.58	-10.84	87.19	130	0.96	34.33	-0.96	-50.50	49.49	2,253	0.76	7.03	-0.51	-8.54	89.38
Business and repair services	794	1.32	38.02	-0.02	-1.44	62.20	66	0.00	0.00	0.00	0.00	100.00	728	1.58	41.55	-0.03	-1.57	58.79
Personal services	1,103	0.50	10.61	-0.13	-5.20	87.31	132	0.94	20.18	0.94	48.99	100.00	971	0.42	8.89	-0.32	-12.54	85.59
Entertainment and recreation services	311	0.34	22.82	0.08	12.49	82.18	0	0.00	0.00	0.00	0.00	100.00	311	0.40	22.85	0.10	12.49	82.18
Professional and related services	5,382	2.28	10.91	-0.61	-5.05	88.10	982	3.16	12.59	0.70	4.90	91.44	4,400	2.12	10.54	-0.86	-7.27	87.36
Public administration	3,264	2.12	16.82	-1.30	-17.55	76.92	542	1.92	14.93	-1.93	-24.35	75.64	2,722	2.16	17.18	-1.18	-16.19	77.18

*The index of inconsistency may exceed 100 when the assumptions underlying the estimator are not met.

[1] See "U.S. Censuses of Population and Housing 1960, Principal Data Collection Forms and Procedures" for an explanation of single stage and two stage areas in 1960 Census.

[2] Estimate of number of persons is according to ERC classification. It includes estimates for only those persons whose occupation or industry was reported in both the ERC and Census.

Source: The Employer Record Check, Series ER60, No. 6, Bureau of the Census, U. S. Department of Commerce, p. 14.

TABLE VII

COMPARISON OF THE PERCENT IN ERC AND PES CLASSIFICATIONS IDENTICALLY REPORTED*

Primary Job Title	1950	1960
Professional, technical and kindred workers	89%	89%
Managers, officials, and proprietors, except farm	76	57
Clerical and kindred workers	87	83
Sales workers	82	89
Craftsmen, foremen, and kindred workers	81	82
Operatives and kindred workers	82	84
Service workers, except private household	86	84
Laborers, except farm and mine	66	50

Source: 1950 figures calculated from Table I, using formula in ERC, p. 6; 1960 figures from Table VI.

*It should be kept in mind in reading this table that the ERC (1960) was an employer check on census, whereas the PES (1950) was a post-enumeration survey of census, or a re-survey of households. The two are not strictly comparable.

205). I endorse the recommendations of the committee for better occupational statistics, and urge these recommendations be implemented as soon as possible."[7]

The second main source of occupational data on a national basis is the Current Population Survey (also referred to as the Monthly Report on the Labor Force or M.R.L.F.). Unfortunately this is also a household survey and thus suffers from the fact that like the census the job title information is undependable. The enumerators for the Current Population Survey are most skilled. However, the PES and ERC surveys of the 1950 and 1960 censuses proved that, particularly in the occupation and industry questions, the role of the enumerator is not crucial. What is required is standardized employer data.[8]

The Gordon Committee summarized their reaction to the M.R.L.F. data as follows:

> Almost the only current reports on employment in various occupations are from the household survey. Although information is collected in much more detail, it is grouped into about 30 broad classes for publication. This is done because the data for most specific detailed occupations are not considered reliable. A major reason is that the number of persons reporting a given occupation in any one month in the present survey is too small to constitute a statistically reliable sample. Another reason is the difficulty of obtaining accurate information from the housewife or other family respondents to questions about the occupations of all employed household members. The reply is often ambiguous or incomplete; frequently the worker himself does not know the proper title for his occupation.
>
> Despite these weaknesses, the Committee recommends that more use be made of the household survey to obtain occupational distributions. It should be noted that the survey is the only source of information for unpaid family workers and for many categories of the self-employed, and that it is especially valuable for those occupations, such as construction, in which workers shift back and forth from wage and salary work to self-employment.

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[7] Improved Statistics for Economic Growth, A Compendium of views and suggestions from individuals, organizations, and statistics users, Joint Economic Committee, July 1965, p. 47. However, one would hope that whomever compiles the employer occupational data is as dedicated and responsible as Census and provides an independent check on the data (as ERC provides a check on Census).

[8] See Concepts and Methods Used in Household Statistics on Employment and Unemployment from the Current Population Survey, June 1964, BLS Report No. 279, Current Population Reports, Series P-23, No. 13. Also see ERP, Series ER60, No. 5, Accuracy of Data on Population Characteristics as Measured by CPS-Census Match, especially pp. 37-49. The percent in CPS professional class identically reported was 89.38%; for managers 65%; and for laborers 59%.

Several possibilities present themselves for improving the survey results. The quality of response to occupational questions could be improved by the use of special questionnaires to be left by the interviewer and mailed in by all employed persons in the household. Special surveys could also be made in which the worker is interviewed directly. The problem of high sampling variability in many occupational classifications could be reduced by the occasional use of a much larger sample than the present monthly survey. Even with the present sample, it would be entirely feasible to accumulate the data now collected monthly for a given occupation over a period of several months or a year to obtain distributions of greater reliability.

Despite the desirability of increased use of the household survey, the Committee believes that, for detailed information on individual occupations, reliance must be placed on information from employers. This source is presently used to provide data on only a few occupations. The Bureau of Labor Statistics collects information annually on scientific, technical, and engineering personnel from employers by means of a mail questionnaire. Occupational statistics are also collected as a by-product of wage-rate studies conducted by the BLS for specific industries or communities and in connection with local-area skill surveys of the Bureau of Employment Security. A number of Federal agencies, such as the Interstate Commerce Commission and the Civil Aeronautics Board, collect occupational data for the industries they regulate.[9/]

The M.R.L.F. data are being used for long-term manpower projections by the BLS because they provide the only complete estimates between census years. The manner in which they are employed and the method for reconciliation with the census is described by Harry Greenspan.[10/] However, even on a national basis Greenspan warns, "Our interest extends beyond the broad occupational groups to specific occupations. Doubts about broad group estimates in the Census are likely to be sharpened when we consider detailed occupations. Any errors in the broad group estimates in the Census are averages of errors for the detailed occupations in the group, and a broad group estimate in the Census which appears reasonable in total may result from offsetting errors for individual occupations." Thus the evaluation of the gross errors in PES and ERC are important when one attempts to proceed from the major occupational groups to the more specific occupations. Even more difficulties present themselves when one proceeds to specific occupations in specific SMSA's.

[9/] Measuring Employment and Unemployment, President's Committee to Appraise Employment and Unemployment Statistics (The Gordon Committee), 1962, p. 203.

[10/] "Estimates of Employment Requirements by Occupation for Future Periods --Data Sources and Model Development," pp. 49-52, in Long-Term Manpower Projections, Proceedings of a Conference conducted by the Research Program on Unemployment and the American Economy, Institute of Industrial Relations, University of California, Berkeley, June 25-26, 1964 (mimeographed), R. A. Gordon, editor.

TABLE VIII

EMPLOYMENT ESTIMATES FOR SELECTED OCCUPATIONS, CENSUS AND OTHER SOURCES, 1960

Occupation	Employment (in thousands) Census	 Other source	 Census as a % of other source	Description of other source
Engineers[1/]	681	649	105	B.L.S. Survey of Employment of Scientific and Technical Personnel in Industry
Chemists[1/]	67	77	87	
Draftsmen[1/]	186	210	89	
Dentists	83	87	95	Licensure statistics
Professional nurse	582	504	115	Joint estimate of the Inter-agency Conference on Nursing, and Statistics based on a variety of data
Student nurse	57	115	50	Enrollment statistics
Pharmacist	92	117	79	Census of N.A.B.P. members and licensure data
Physician	229	225	102	Membership records of A.M.A. adjusted
Veterinarian	15	20	75	Membership of A.V.M.A. plus known nonmembers, less retired
Telephone operators[2/]	220	218	101	Data submitted to the Federal Communications Commission
Postmaster	36	35	103	Post Office payroll records
Postal clerk and supervisor	212	258	82	
Mail carrier	196	204	96	

[1/] Includes private wage and salary workers outside of colleges and universities and non-profit organizations.

[2/] Telephone industry only.

Source: Long-Term Manpower Projections, op. cit., p. 54.

What Greenspan and Taylor hold out considerable hope for is the special studies based on good information for one or a few occupations. Greenspan presented a table summarizing these various "other sources," according to the occupation they cover. In addition, occupational estimates may be developed as a by-product of the BLS wage-rate studies for about thirty occupations, and there will be additional occupations covered, such as those for which the Civil Service Commission collects data. All in all, an impressive number of occupations will soon be traced on a fairly current basis, covering perhaps 10,000,000 workers.

For a regional breakdown of the occupational data, only two additional possibilities exist. First, there are the BLS and BES payroll and unemployment insurance data which permit good estimates for employment by industry on a current basis. No occupational data is gathered, except in very gross form, but the current employment data would be useful if, and this is an important qualification, occupational profiles by industry were applicable to the region or SMSA. The second type of data available are the area skills survey data. These are done by the local state employment offices and are based on interviews and questionnaires with employers. Unfortunately, the studies of employer estimates of employee needs are not too encouraging. What appears to be the ideal combination is standardized employer data on a current, continuing basis, but analyzed by occupation, industry and region on an overall basis by economic and business experts. Since the ideal type of data will not soon be available, we must proceed as best we can with the information now available. Hopefully, the short-run plans for extending and improving the current information will proceed along the lines of the ideal long-run solution.

THE PROJECTIONS

In the previous two sections "ideal" methods for projections were developed assuming "ideal" data were available, and then the actual data that presently exists was critically examined. Our current task is to decide what it is that we are trying to project, develop measures to evaluate our projections, and then recommend methods to use.

There is more than meets the eye to the question, "What is it that we are trying to project?" Obviously we are trying to project occupational needs for an SMSA in 1970 and 1975. But are these occupational needs defined as what the 1970 census says they are, or are they what will exist in the real world, or are they what might be measured by a new statistic or survey made in 1970 or 1975? If we were to try to anticipate the results of the 1970 Census, then the problem would be straightforward. Errors in the previous census data might not bother us because most of these errors will also be included in the future censuses and they might be fairly consistent. The fact that the census information, particularly for occupations and industry employment, have only a tenuous and unknown relationship to what happens in the real world is not important, if the first approach is adopted. All one need assume is that the task requires a projection of the 1970 Census results (or 1980 or 1990) and the degree of success is measured by how close the estimates come to the "actual" census results. However, such estimates might be poor guides to vocational and educational policies -- unless the assumption can be made that the errors in the censuses can be corrected for by the statisticians or the educational authorities. Since there is no way of evaluating these errors in the detailed occupational breakdowns, even at the national level, let alone at the SMSA level, the census approach is not hopeful.

The second method, to compare projections against what is happening in the real world, also presents grave difficulties. The "real world" in this case consists of a set of jobs and job vacancies that will exist in the Denver SMSA in 1970. These approximately half-million jobs and job openings must be classified and tabulated, in order to become known to the researcher. The census is one method of attempting to estimate "the facts" in the "real world." However, if the census is not used, some other categories must be established and the tabulations must then be carried out. There are no methods of getting at the real world of Denver's jobs in 1970, other than by surveys and counting. It is possible to follow the supply and demand situation of the Denver labor market, as exhibited through employment offices or advertisements or personnel department evaluations. However, these are more likely to be inconsistent (from period to period) and more open to error than even the census. They undoubtedly provide valuable bits of information in specific occupational areas, but for an overall estimate of the Denver labor market they too will not provide a reliable guide. Therefore, it is essential that some quantitative estimates of the set of jobs in the Denver SMSA in 1970 be agreed upon to serve as a guide to the "success" of the projections and to serve as a guide to future improvements in data and method.

The third method is to try to anticipate new measures that might be used for checks on occupational projections. At least two kinds of such measures are presently being collected and might be adapted for this purpose. The specialized occupational information collected by BLS from already existing material, partially summarized in Table IX, would also, in many cases, be available on a state or SMSA basis. For example, licensure statistics and association statistics would provide good estimates of the number of dentists, doctors, veterinarians, pharmacists, and other similar occupations on a state and SMSA basis. These checks, when applied with other key ratios, might well provide reliable guides to occupational projections. Similarly, the industry totals for employment are collected by both BLS and BES on a regional and SMSA basis. Since so much of vocational training in the blue-collar fields is presently oriented to an industry (i.e. the air conditioning industry, the electronics industry, the automobile repair industry, etc.) the regional data of employment by industry is important. If, in addition, limited occupational profile information can justifiably be applied (perhaps derived from national studies or case studies), then the industry-employment statistics become even more valuable. What these two additional measures finally amount to is column and row totals for a regional or SMSA occupational matrix. Since data presently available does not permit reliable estimates for the body of the matrix, the most satisfactory method is to verify the projections with the row and column totals. The industry employment series of both the BLS and BES are continuous and reliable for the Denver SMSA, although knowledgeable reconciling of the two would be helpful. The occupational data is available for selected professions

TABLE IX

COMPARISON OF EMPLOYMENT BY INDUSTRY, DENVER SMSA, APRIL 1960, CENSUS AND BLS

Industry	1960 Census SMSA	April 1960 BLS SMSA	Census as % of BLS
(1)	(2)	(3)	(4)
Total employment	353.1	-	-
Agriculture, forestry & fisheries	7.0	-	-
Nonagricultural employment[a]	346.1	323.9	106.9
Mining	3.3	4.3	76.7
Construction	24.7	21.6	114.4
Manufacturing	67.6	61.8	109.4
Nondurable goods	33.3	30.0	111.0
Food and kindred products	11.5	12.3	93.5
Meat products	3.3	3.8	86.8
Dairy products	1.7	1.8	94.4
Bakery products	2.8	2.7	103.7
Other food and kindred products	3.7	4.0	92.5
Textiles, apparel & leather	3.8	3.5	108.6
Printing, publishing & allied industries	6.9	5.6	123.2
Chemicals & allied products	2.6	1.5	173.3
Rubber & miscellaneous plastic products	5.9	5.4	109.3
Other nondurable goods	2.5	1.7	147.1
Durable goods	34.0	31.8	106.9
Lumber & wood products, including furniture	1.5	1.7	88.2
Stone, clay & glass products	3.0	3.1	96.8
Primary metal industries	1.6	1.4	114.3
Fabricated metal products[b]	14.8	14.9	99.3
Machinery, except electrical	5.1	4.4	115.9
Electrical machinery	2.6	1.7	152.9
Transportation equipment	2.7	2.6	103.8
Other durable goods	2.7	2.0	135.0
Not specified manufacturing industries	0.2	-	-
Transportation & public utilities	30.0	29.4	102.0
Railroad transportation	5.4	5.5	98.2
Motor freight transportation & warehousing	7.1	7.7	92.2
Transportation by air	3.6	4.1	87.8
Other transportation	2.3	1.5	153.3
Communication	6.5	7.1	91.5
Electric, gas & sanitary services	5.1	3.5	145.7
Wholesale and retail trade	74.8	80.0	93.5
Wholesale trade	17.4	25.7	67.7
Retail trade	57.4	54.3	105.7

(in thousands)

(continued)

TABLE IX (cont.)

Industry (1)	1960 Census SMSA (2)	April 1960 BLS SMSA (3)	Census as % of BLS (4)
	(in thousands)		
General merchandise, apparel & accessories	13.9	14.0	99.3
Food stores	9.3	8.2	113.4
Automotive dealers & gasoline service	8.5	8.2	103.7
Eating & drinking places	10.9	11.6	94.0
Other retail trade	14.8	12.3	120.3
Finance, insurance & real estate	20.7	19.0	108.9
Finance, insurance, & holding & other	15.4	15.3	100.7
Real estate & combination offices	5.3	3.7	143.2
Service & miscellaneous (excluding gov't. educ.)	69.2	50.8	136.2
Hotels, tourist courts, & motels	5.1	5.0	102.0
Laundries, laundry services & cleaning	3.7	3.9	94.9
Miscellaneous business & repair services	10.6	7.8	135.9
Amusement & recreation services	3.3	3.1	106.5
Medical and other health services	17.9	12.1	147.9
Educational services (private)	4.9	4.8	102.1
Other service & miscellaneous (excl. educ.)	23.6	14.1	167.4
Government (including education)[c]	42.2	57.0	74.0
Federal	17.3	21.7	79.7
State & local (including education)	24.9	34.4	72.4
Industry not reported	13.8	-	-

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[a] Census figures may be larger than BLS figures because BLS excludes domestic servants, firm members, proprietors, self-employed persons, and unpaid family workers. Also, in any particular category, census includes government employees who are working in that industry; whereas BLS puts all government employees in the category "Government." In particular categories, BLS figures may be larger than census figures because census excludes employees under 14 years of age and some part-time workers. In addition to the exclusions in each set of statistics, census figures may be larger or smaller than BLS figures because census is household data and may include those living in the SMSA but working outside the SMSA and exclude those living outside the SMSA but working inside the SMSA; whereas BLS data are establishment data. Also, census figures may be larger or smaller than BLS figures because of the possibility of response errors in the collection of the decennial census. There also could be a difference in some sectors because of the difference in the reporting period between the two sets of data.

[b] BLS figure for "Ordnance" included in "Fabricated metals."

[c] The major difference between the census and SIC classifications is that BLS includes all those who receive their pay from a public agency in the category "Government," whereas census includes in the correlative category, "Public Administration," only those workers who are employed in the uniquely government

(continued)

TABLE IX (cont.)

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services. All other government employees are placed by Census in the industry sector in which they are working. In this table, census figures for "Government," include those workers in the census categories "Public Administration" and "Educational Services: Government." In the published census, the latter category is in the "Professional and Related Services" sector.

NOTE: Only the two major differences between the census and SIC classifications have been adjusted. Adjustment of the more detailed differences would probably make the two series more comparable.

Source: Derived from data in _U. S. Census of Population: 1960, Detailed Characteristics, Colorado_, Final Report PC(1)-7D, U. S. Department of Commerce, Bureau of the Census, Washington: U. S. Government Printing Office (1962), Table 127, pp. 332-333; and "Estimated Nonagricultural Employment in the Denver Area for 1960," U. S. Department of Labor, Bureau of Labor Statistics, Denver (mimeographed).

and occupations, and the data appears to be quite reliable. The major drawback is that most of the occupations are in the professional fields (physicians, dentists, optometrists, veterinarians, registered nurses, etc.). However, some series are available in occupations that hold great interest for vocational training (cosmetologists, barbers). If occupational projections for an SMSA, such as Denver, are compared to these row and column totals it should still be kept in mind that the totals are not the "real" world. They are estimates of industry and occupational employment for a given time period within a given region. Once again, sampling errors, coding errors, and mechanical errors are likely to be of relatively minor importance compared to errors of classification. However, these classification errors will probably be of a far smaller order of magnitude than in the census. (See Table VII.) With an understanding of what we want to project and how the "goodness of fit" might be approached, each of the major methods will now be discussed.

Each of the methods for occupational projections have a matrix and non-matrix form. This means that each method can be applied either with a matrix, if the data is available and warrants this approach, or by using more conventional methods. The matrix provides one with a general purpose tool that can be used for each of the methods. At the same time, each method can be applied with conventional tools. Given the imperfect state of occupational data, particularly at the SMSA level, the most fruitful way of exploring methods might be to develop what each approach means when applying conventional tools and contrast this with the same method using the matrix tool.

Method A

Method A is the first naive model and is simply a "no change" model that is useful primarily as a bench mark. In matrix form it would simply mean that the best estimate for each cell is the 1960 figure for the cell. In non-matrix form it means that the column and/or row totals that would be used for 1970 "verification," can best be estimated by the 1960 (or the most recent data) totals.

Method B

The second naive model, which is recommended for use as a second bench mark, involves applying the estimates for national employment growth to each of the cells and totals for the Denver SMSA. For example, if the "best" estimate for national growth in employment that results from the growth study is, say 15% for the decade of the 'sixties, then the flat 15% rate could be applied to each cell of the occupation/industry matrix, and also to each row and column total. Neither of the naive models are meant to be used for serious occupational projections. However, they do provide a guide to the improvement gained by using more sophisticated methods. For example, if one has an estimate for physicians in the Denver SMSA in 1960 of, say 2,000, Model A would "predict" 2,000 physicians for 1970 and Model B (using the arbitrary 15% national growth factor) would "predict" 2,300 physicians. Let us assume that one of the more sophisticated models "predicts" 2,500 physicians for 1970, and the "actual" from the state licensing board, and/or from the Colorado Medical Association turns out to be 2,200. Several possibilities for evaluating the projections now present themselves. The absolute difference between the various predictions is a possibility (200, 100, and 300 respectively). Or the square of the differences (or cube) can also be used, thereby accentuating the larger "errors," and giving additional weight as the "error" grows. But regardless of how the differences are defined, by using Methods A or B we have a guide of "goodness of fit" of the projection. If the sum of the differences of the sophisticated method exceeds the sum of Methods A or B, or is even close to their sum, then the sophisticated method does not rate terribly well. Use of the naive models permits quantitative evaluation of the more sophisticated projection techniques for national as well as SMSA levels.

Method C

The first sophisticated method to be discussed can be termed the historical method. It assumes that the SMSA or region is significantly different, for purposes of the occupational projection, from the national economy or from other regions. If one grants this key assumption, then the SMSA or region is unique and must be studied by itself. This can be done in either matrix or non-matrix form, and several variations of the historical approach are possible. Each will be discussed in turn, although one should keep in mind the possibility of using more than one method.

The first variant of the historical method is projection of past trends. Time series, at various levels of aggregation, are available for the SMSA or region, and these are analyzed and projected. Mathematical methods permit the appearance of objectivity, although each method has its own assumptions, which the analyst accepts as applicable to the problem and data when he makes the decision to employ that method. This is the most commonly applied method and examples of its use for employment projections in the Denver SMSA and Colorado in recent years include the work of Vaughan, Droste, Denver Research Institute, Denver Planning Office, and the matrix model, in reduced form, found in Appendix II by Franks and McCormick. In most cases the simple projections are then modified by the author's judgments usually based on his knowledge of the development of the SMSA; interviews with knowledgeable businessmen, bankers, political leaders, academics, and statisticians; national trends; local series and literature; and particularly the latest "weltanschaung" of the business community. Different levels of sophistication lead to different variants on this historical theme.

In the Denver SMSA case, the broader regional context of the Rocky Mountain eight-state area is one logical starting point for tracing basic trends in historical development. Work by Garnsey and Arrington stress the dependence of the region on primary production resources, and government, including defense. Embracing only 4 percent of the population of the United States, the vast geographical area comprising the Rocky Mountain region is unlikely to blossom into a market center, which is the primary requirement to attract manufacturing industry. Problems of semi-aridity over much of the region, and relatively expensive surface transportation, further compound economic development. At the same time, however, sparseness of population and physical surroundings of great beauty have become amenities of living that are ever more highly prized as the economy becomes more affluent. Given an extremely tight national labor market, the ability to attract good labor would be given increased weight in corporate location calculations. Such qualitative evaluations underlie the sophisticated variant of the historical method, as applied to the long-run. The Denver Research Institute's study, Economic Forces Behind Colorado's Growth 1870-1970, is an example of a modified version of this method applied at an industry level only. Using traditional time series data, projections are placed against a broad historical sweep, and modified by knowledgeable judgments. The occupational profiles would have to be applied to the industry projections to arrive at long-term occupational projections. The I-O counterpart of this approach would involve classifying the sectors into the historically significant categories. Using the 1958 I-O study this would mean taking industries 1-10 (the primary industries) plus industry 13 (Ordnance) plus industries 78 and 84 (Federal Government enterprises and industry). It would be desirable to separate from several other industries those portions that particularly apply to Colorado and the Denver SMSA (industries 60, 74, 72 and 81), but this is impractical. Given several I-O tables for broadly spaced time periods that are consistent and comparable, long-term projections, such as suggested by Leontief and Chenery for developing nations, would be possible. Each region of the United States might have a different developmental pattern for different economic periods and a historical I-O pattern would emerge. If this were coupled with occupational profiles and the projection discussed in section 2 of this report, then long-run occupational projections would result. Qualitative historical judgments are easily translatable into I-O and occupational matrix form. In the case of Colorado and the Denver SMSA these would largely involve judgments regarding the future of the thirteen industries enumerated above. The I-O tables permit immediate access to the indirect effects of these judgments that might otherwise be difficult to evaluate. The Denver Research Institute's study, thorough as it is, does not take explicit account of these indirect effects because no I-O material is available at this sub-regional level. Instead, the indirect effects are implicit in their projections of other related industries and in their application of population ratios in many industries. A formal I-O approach, assuming data and projections were available, would offer a definite step forward from the traditional application of the long-run historical approach.

A second variation of the historical approach is more attuned to the short-run projections and covers all studies mentioned above. Droste does a simple least squares fit to data going back to 1939. The NPA study starts with 1947 data. Vaughan concentrates on the census years 1950 and 1960. And even the Denver Research Institute's study, which stresses data going back to the 1860's, places major emphasis on very recent material. The DRI report, published in February 1963, is a good example of how difficult and treacherous projections can be, particularly in sub-regions and for specific industries or occupations. The Denver SMSA's very rapid growth from 1959 to 1963 can be traced to one major factor, the rise of Ordnance manufacturing. DRI's summary of the outlook for this industry, undoubtedly reflecting industry spokesmen at the time of the report, is as follows:

> Ordnance and Accessories. This industry was practically non-existent in Colorado in 1950 and employed 16,800 persons in April, 1962. The near future market for defense and aerospace products appears to be assured. However, Colorado's participation in these activities is substantially keyed to whatever success the Martin-Marietta Corp. may have in attracting

> new contracts following the present Titan I, II and III projects. Growth of the present Martin operation in Colorado may be limited by Martin-Marietta plant capacity elsewhere, company policy on Colorado employment levels, and by physical limitations on the size of objects or space vehicle airframes which can be completely fabricated in Martin's Littleton plant and transported to prospective launching sites. After considering all these factors it appears that Martin employment in Colorado will remain at present levels (about 13,500) through 1965, but range from 10,000 to 20,000 by 1970.[11]

By 1965 the Martin employment was half that estimated and the picture for 1970 is not too favorable. But so much of the Martin employment depended upon the performance of alternative vehicles, as well as the factors cited in the report, and these were largely unpredictable. An occupational projection based on the DRI report for the Denver SMSA would have been heavily weighted toward skilled craftsmen, professionals, and engineers. Actually the Vaughan projections, based on the 1960 census, lean in this direction. Occupation projections for a relatively small sub-region are open to exceptionally wide variation. A single plant or industry can often, in the short run, make the difference between a projection being "realized," and a projection being very wide of the mark. It appears that the overall projections for the Denver SMSA by most of these studies (all running between 470,000 and 500,000 gainfully employed for 1970) might well be realized. The unexpected rapid growth of the national economy and several favorable local factors make the 1970 estimates well within realistic attainment. Most of the estimates were made at a time when Denver's employment was already 430,000. An earlier DRI projection made for the Water Commissioners in 1958 was more conservative because it preceded the Martin expansion. The earlier estimates ran from 450,000 to 460,000. However, it must be kept in mind that the most commonly used projection of 480,000 is a conservative figure, particularly when viewed against the 1950 to 1960 expansion. From 1950 to 1960 about 120,000 new jobs were added to the Denver SMSA for a percent increase of slightly more than 50%. The 480,000 projection for 1970 adds only 130,000 new jobs for a percent increase of about 37%. The actual "realized" figure for 1970 will lie between 430,000 and 500,000, but there is little help given by the short-run historical approach in the attempt to narrow the estimate. This method warns us how imprecise are sub-regional occupational projections.

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[11] Denver Research Institute Report, p. 116.

The matrix equivalent of the short-run historical method is shown by the reduced Franks-McCormick model. They calculated matrices for the census data of 1930, 1940, 1950, and 1960. Linear and non-linear "best fit" relationships can be calculated for a single cell in the matrices using two or more census years. Similarly, groups of occupations or groups of industries can be summed, and similar relationships established. These projections do not involve a complete system, but omit projections for demand, production functions, and occupational profiles. They simply extend into the future a "best fit" relationship from the past. Although when presented in matrix terms, the short-run historical method appears stark and arbitrary, in actuality it is the same method used by Vaughan, Droste, DRI, and by most other "projectionists." When seen in matrix form, it is bereft of verbal trappings and the assumptions come through clearly. There is much to be said for any method that makes its assumptions clear and obvious. Review of the short-run projections highlights the arbitrariness of SMSA projections in which final demand shifts can result in employment increases (between 1963 and 1970) from zero percent to fifty percent. Each of these projections depend upon the amount of assumed "outside" purchasing power brought into Denver and Colorado in the form of new jobs, based upon "exports" or the servicing of individuals whose incomes are derived from outside the SMSA and state. Since there is little stress placed on these "outside" sources of jobs and income in the short-run projection technique, this particular method is not helpful in effective demand projections, and thus in occupational projections for an SMSA where final demand is volatile.

Method D

Method D is called the "ideal type" approach. Assume that all industries can be grouped into three or more meaningful categories. If the classification follows the traditional primary (P), secondary (S), and tertiary (T), then logically there are seven ideal types possible. The first would be categorized by a preponderance of primary, which was true of Colorado in the mining era. The second would be categorized by a preponderance of secondary, or manufacturing. The third a preponderance of tertiary or service industries. The fourth would emphasize both P and S. The fifth, S and T. The sixth, P and T. And the seventh ideal type would have a "balance" of all three activities. At present the Denver SMSA fits in the sixth type where primary and tertiary activities are relatively more important than the secondary. The evidence of primary activity is indirect, with the servicing of agriculture and mining by Denver industries. The seventh type, it will be recognized, is the one where the SMSA mirrors the national economy and thus where the national projections can be proportionately reduced and applied to the SMSA.

The matrix version of this method is greatly simplified by the industry organization of the 1958 I-O study. Relatively few industries appear to be "hybrids." The following tabulation is a first approximation to the three industry categories:

	Primary	Secondary	Tertiary	Hybrid (requiring further breakdown)
Industry number	1-10, 14	13, 15-64	65-84, 86	11, 12, 85

The classification, which follows the traditional breakdown, gives some credence to the gross primary, secondary, and tertiary categories. Whether such a breakdown is helpful to occupational analysis is the question for this study. Although the triad analysis might aid in final demand analysis for an SMSA and a sub-region, it is doubtful whether occupational groupings would fall more readily into the three classifications than in some other type of grouping. It is true that certain types of business organization are associated with the tertiary industries (small business, individuals, and governments), but the occupational requirements for these same industries are quite disparate. It would include auto mechanics, laundry workers, laboratory scientists, lodging place cleaning personnel, teachers, television technicians and stars, doctors, office supply clerks, railroad switchmen, telephone linemen, postal executives and clerks, bankers, and insurance salesmen. It would appear that an occupational breakdown, of the kind discussed in Method F, would be more suitable for job projections, than such a grouping of industries. Even if this is true, however, the importance of the industry analysis for final demand projections remains. And for a subregion such as the Denver SMSA, the overriding consideration might well be demand

A variant of Method D that emphasizes demand is the Harms or industry base approach. Industries in a given locality are grouped by "analytical industrial category" which provides a framework for arriving at an industry's export earnings capacity. Core industries are traced through an I-O matrix for direct and indirect effects. Service industries related to the number and kind of people are then added to the core. Finally, all other industries are added. For example, livestock is a core industry for Colorado. A certain number of other industries depend upon the livestock industry, such as the veterinarians, food and kindred products, drugs, and even, to some extent, the telephone industry (included in 66, communications, except radio and TV). But the individuals and their families that are directly and indirectly dependent upon the livestock industry purchase, as consumers and taxpayers, many final products. The final products purchased by these consumers, as well as the final products purchased by them as part of the livestock industry (direct and indirect) also give rise to many intermediate activities, such as office supplies, wholesale and retail trade, trucks, and farm machinery and equipment. This description of the interdependencies is done in this great detail in order to emphasize that the I-O version of the regional base study (or the Harms study) provides an excellent framework for analysis. The Harms approach, among others, uses an export quotient, or locational quotient, to estimate employment associated with the export of goods and services from an area. If possible, an SMSA I-O table with a reasonable and clear "export" sector is likely to be far more reliable because it will be derived from the business records of shipments outside the sub-region or SMSA. Similarly, the indirect effects traced through a Harms type industry pyramid cannot be as comprehensive as an I-O table similar to the 1958 study. Unfortunately, such I-O tables for sub-regions are very scarce. The Harms approach yields a working substitute that does approximate the matrix approach. Of course, both the I-O and the Harms approaches still only yield industry estimates. Occupational profiles remain to be superimposed on these industry projections to yield the occupational projections that we need.

A final industry grouping to be considered is the classification used by the 1958 I-O study and applied by the N.P.A. The industries, and the related SIC codes, are given in the Survey of Current Business (November 1964), p. 17. They consist of the following nine major categories:

Agriculture, forestry & fisheries
Mining
Construction
Manufacturing
Transportation, communication, electric, gas & sanitary services
Wholesale & retail trade
Finance, insurance & real estate
Services
Government

If it can be shown that this classification of industries is helpful in projecting occupational requirements, then a most useful task will have been accomplished, because historical data for these categories is available by sub-region. Unfortunately, no such neat link between major industry groups and occupational groups has been established. A simple matrix with major occupation and major industry might prove useful as a good first approximation for SMSA analysis, particularly in view of the reliability of the total row and column data.

Method E

Method D, broadly interpreted, grouped industries into a pattern which would permit a more meaningful approach to occupational projections. Method E would group occupations into classifications with the expectation that these categories would make the occupational projections more manageable. The first grouping that comes to mind is the one that is widely used and for which there is a great deal of reliable data, the major occupational groups.

Professional, technical and kindred	)	
Managers, officials and proprietors	)	white collar
Clerical and kindred workers	)	
Sales workers	)	
Craftsmen, foremen and kindred workers	)	
Operatives and kindred workers	)	blue collar
Laborers	)	
Private household workers	)	service workers
Service workers except private household	)	
Farmers and farm managers	)	farmers and farm workers
Farm laborers and foremen	)	

Analysis of this data permits broad and useful generalizations about the trend of these major categories, such as the rapid contraction of the farm categories and the rapid increase in the professional, technical and kindred group and also in the service workers, except private household. A summary of these national trends, projected to 1975, is found in the Monthly Labor Review for April 1965, pp. 379-383. A similar summary of the major industrial groups appeared the month before. Similar generalizations can be made at the SMSA level, and Table X provides the data for Denver, on a percentage basis.

TABLE X

MAJOR OCCUPATION GROUP OF EMPLOYED PERSONS, 1950 AND 1960 MALE, DENVER SMSA, PERCENT OF TOTAL EMPLOYED

	1950		1960	
Professional, technical & kindred	11.8%		15.9%	
Managers, officials, proprietors	14.0		14.2	
Clerical and kindred	8.4		8.6	
Sales workers	8.6	42.8	8.7	47.4
Craftsmen, foremen	19.5		19.8	
Operatives and kindred	15.2		15.8	
Laborers	7.2	41.9	6.7	42.3
Private household workers	.1		.1	
Service workers	7.5	7.6	6.9	7.0
Farmers and farm managers	2.6		1.2	
Farm laborers	1.7	4.3	.9	2.1
Occupation not reported		1.3		1.3

Source: U. S. Census of Population 1950 and 1960, General Social and Economic Characteristics, PC (1)-1C, adapted to make "occupation not reported" uniform for both years.

The relative trends for Denver were not as clearly defined as they were for the United States. The rapid increase in the professional and technical category was inflated to some degree by the Martin employment. Every 2,300 workers constituted one percent in 1960. Thus the Martin increase by 1960 of about 10,000, heavily weighted as it was with professional and technical, must have accounted for a good deal of the increase. The net shift between censuses then becomes the decrease in the farm categories offset by the increase in professional and technical -- perhaps a shift of about two percent of the employed male labor force. From 1950 to 1960 there was an increase of about 71,000 male employees in the Denver SMSA, but the shifts that occurred from one major occupation group to another were not great.

These kinds of statements are useful, but do not provide educational authorities with the guides they need for short and long-run planning. Vocational and technical education can, broadly speaking, be divided into white collar training and blue collar training. The white collar courses are oriented to teaching skills, without reference to the type of industry the student will eventually enter as a worker. The blue collar courses, in contrast, are usually oriented to the industry. The stenographer or IBM key punch operator is able to take any job that is available and the employer expects to train each new white collar worker to adapt to the special requirements of his industry and operation. The blue collar trainee, on the other hand, is often able to offer his services only to the industry in which he is trained, and sometimes only for a specific kind of job within that industry. In some ways this traditional inflexibility has made occupational projections and vocational training much easier and more reliable. Industry projections are all that are required. There are many indications that the industry approach is breaking down and additional flexibility and mobility is required. Basic skills in arithmetic, English, and general shop practices become more important as continuous change and re-training sets in. Can there be meaningful occupational groupings formed within the blue collar fields that vocational training will be useful to vocational training planning? Three levels of analysis are involved. First, there are the job openings toward which the training should be oriented. Second, there are the vocational courses that have evolved to fulfill previous needs. Third, there is the supply of trainees with their backgrounds, previous training and experience, and present attitudes and outlooks. As long as training is geared to an industry, advisory committees from industry and labor can transmit to vocational training leaders on a regional and national basis their outlook of supply and demand conditions, and their advice on how to make the programs more useful and effective. As cross-industry mobility increases, either from necessity or from choice, specific skills may become more important and the blue collar field may become more similar to the white collar. Running the controls of an automated oxygen steel furnace may be more similar to running the controls of an automated bakery than it is to tending an open hearth furnace. Personnel and vocational studies are required to guide us here. Pure statistical research into occupational projections are not enough. If the personnel and vocational studies show that five or six main streams of vocational and technical training serve to prepare the student for most of the blue-collar occupations, then we should group these production jobs according to the five or six streams and project occupational needs by these major groups' skills.

Method F

The final method of projecting occupational requirements for an SMSA is to relate the SMSA to the national economy. Every SMSA or sub-region has close ties with the overall economy. The rate of growth of the United States has a profound impact on all of the sub-regions, probably the most important impact of any single force. In addition, there is a great homogeneity in the development of the economy, despite regional differences, and the degree of homogeneity is growing all the time. The manner of living in even the most sparsely settled Rocky Mountain state is more similar to the manner of living in California or New York than it is different. The role and kind of the automobile, telephone, television, schools, roads, hospitals, clothing, food, housing, appliances, reading material, etc. is remarkably uniform. This means that most of the occupations and services in Boise, Idaho, are quite similar to those in Los Angeles, California, and New York. The following table for the Denver SMSA, with manufacturing occupations omitted, underlines how similar is the occupational profile, once the sole cause of the difference is removed (in this case the low percent of those employed occupied in manufacturing).

If an SMSA grows at a faster rate than the U. S. economy (in terms of employment), it must mean that either the more labor intensive industries are growing faster than the U. S. counterparts, or there is a shift in the SMSA away from less labor intensive industries toward more labor intensive industries. This approach is adapted from the N.P.A. method and can be translated into matrix I-O form. One would group the 82 industry sectors by labor requirement intensivity. At least two I-O tables, in terms of labor requirements per dollar of industry output, would be needed for the sub-region and the U. S. For example, if we had the 1947 and 1958 I-O tables for Denver SMSA and for the U. S., we could interpret the changes in employment in this manner. If neither the industry mix (from a job intensivity point of view) changed nor the rate of growth of Denver's industries as compared to U. S., then Denver's employment growth would equal the national employment growth. Any difference in rates of employment growth (either positive or negative) could then be broken down into the two components (different rates of growth of different industries, or changes in the industry mix).

The first variant of Method F is a sophisticated version of the "ideal" projection method discussed in the second section. A far more straightforward variant would be to ascertain the relationship between the SMSA occupational

TABLE XI

PERCENT OF THOSE GAINFULLY EMPLOYED IN DENVER SMSA AND 211 SMSA's DISTRIBUTED BY MAJOR INDUSTRY FOR 1960 WITH MANUFACTURING EMPLOYMENT REMOVED

	Denver SMSA	211 SMSA's
Agriculture, forestry & fisheries	2.4%	2.2%
Mining	1.1	.6
Construction	8.6	7.8
Transportation, communications, utilities	10.5	10.7
Wholesale and retail trade	26.2	26.5
Finance, insurance, real estate	7.2	7.5
Business and repair services	3.7	4.1
Public administration	9.1	7.8
Personal services	7.4	6.7
Industry not reported	4.8	6.9

Source: U. S. Census of Population 1960. The totals do not add to 100% because not all industries were available on a comparable basis. The Denver SMSA adds to 81.0% and the 211 SMSA's total 80.8%, sufficiently close to permit comparison.

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matrix and the national matrix, and observe how these change over time. The rates of change can then be projected and the SMSA matrix estimated for a future time. In non-matrix form this can be approximated by use of proportionality relationships, similar to those used by Vaughan to check his other methods. A good starting table for the Denver SMSA in 1970 could be obtained by multiplying each non-manufacturing cell in the national matrix by .007. Each manufacturing related occupation and industry would be multiplied by .004. (These ratios are calculated from the assumptions that the Denver SMSA remains about .006 of the national, and that the percent of Denver's employment in manufacturing remains about two-thirds of the U.S. This results in Denver's non-manufacturing employment being .007 of national and Denver's manufacturing employment only .004 of national.) This would be modified further by increasing food processing occupations within manufacturing, and reducing the others proportionately. Similarly, government occupations would be increased slightly, and the remaining occupations reduced to emerge with the same sum. This calculation assumes that manufacturing in Denver will remain two-thirds of what it is nationally, and that all non-manufacturing occupations will expand at the same rate their national counterparts expand. If these assumptions do not appear valid, others may be substituted that more accurately represent what the estimator believes the proper relationship between the national economy and the Denver SMSA.

Each of the sophisticated methods for projecting will result in good estimations. Actually they will all agree on the estimations, if the assumptions are made consistent with one another, because they really are analyzing the same bundle of experience from four different points of view. Estimations of occupations based on industry analysis should agree with those that are based on occupational analysis, and both should agree with the relationship of the Denver SMSA to the national economy. Finally, all three projections should be consistent with the historical development of the Denver SMSA. The difficult question that now presents itself is how to choose the best method, given the data and given the present state of development of national occupational projections.

CONCLUSIONS

Method E (analysis by occupation) and Method D (analysis by industry) hold the most promise for occupational guides both for the short-run and long-run. The criteria established in the projection section (naive model B) favors Method E because the data against which the estimates would be measured would be the same as that used in Method E. Method E is the "rows only" approach, where the occupations are grouped and re-grouped, depending upon available data, depending upon the proposed structuring of vocational training (particularly in the blue collar occupations), and depending upon the degree of success of the projections (which in turn depends upon the homogeneity of the occupational categories established).

Method E could be started immediately, for as many sub-regions as desired. Occupational data from licensing agencies are readily available, and can be supplemented from other state agencies, Civil Service Commission, and other sources. It is even possible that some major employers in an SMSA would cooperate and make available their own work force figures broken down by major job description categories. For the Denver SMSA it was found that the licensing agencies were most cooperative, during a preliminary exploration of this method, as were those professional associations approached. As the data was compiled, it could be assembled both in traditional and matrix form. However, since it would best be done on as wide a scale as possible, it is important that uniform occupational definitions be established early.

The occupational definitions would undoubtedly follow from those presently in use, but the present interest in job projections presents an opportunity to re-examine the occupational categories with an eye toward making major revisions. These revisions might be of two types. First, usefulness of the categories in vocational training and guidance should be carefully explored. Second, an up-dating of the major occupational categories appears overdue. At present the major categories give insufficient detail to be useful, but the PES and ERC studies showed that even present detail is not supportable by the data. A careful SMSA and sub-regional occupational breakdown might provide reliable detail with which several new major occupational groupings could be experimented.

An important extra benefit that would follow from application of Method E would be the derivation of bench mark data against which Census and M.R.L.F. could be compared. These would complement the household data. At the same time, the move toward uniform definitions and the experience with gathering the information from employer sources would provide excellent guides to the problems and procedures attendant on widespread employer occupational reporting.

Method D, the columns only approach, logically and practically is coupled with Method E. As data are gathered for a specific occupation in Method E, they could also be analyzed by industry. Some occupations are restricted to a single industry (railroad switchmen, telephone linemen, college professors) and thus collecting occupational data automatically means collecting industry data. In addition, if employers cooperate with the data collection under Method E, the information would automatically be reported by industry. Vaughan in his study of the Denver SMSA listed all major employers in the area by SIC industry. If the perspective is to link together the SMSA information in a manner consistent with the I-O national table, then the industry categories at the local level would have to be adjusted to the 82 sectors established by Commerce. Method D, as is true for Method E, would provide bench mark data for Census and M.R.L.F., and would be exceptionally useful to vocational training programs, as long as these programs retain their industry orientation. However, the data gathering problem would be more difficult than for Method E, unless widespread employer cooperation were found.

Methods C (historical) and F (national), important as they are, tend to be less immediately applicable than do the other two methods. This is true for several reasons. Data is the crucial problem in job projections. Methods E and D will contribute greatly to improvements in the data. Methods C and F will, if anything, serve to hamper these improvements because they tend to legitimize present data-gathering methods (by using existing data and endowing it with policy usefulness, when the accuracy of the data does not justify such use). Methods C and F will continue in any case with such studies as those made by the N.P.A. and the DRI because these methods are essential for regional development analysis. Occupational projections will undoubtedly derive some benefit from such studies. However, comparison of the DRI and N.P.A. projections for Colorado with naive model B indicates that these methods should not be encouraged until further improvements in data and methodology are made.

Actually, Methods C and F will benefit greatly from progress in Methods E and D. If Methods E and D were to go forward, it would not be difficult to begin applying both the historical and national approaches, and they would provide valuable supplemental support, particularly for long-run projections.

APPENDIX I

a. METHODS AVAILABLE FOR MAKING EMPLOYMENT PROJECTIONS

b. DATA AVAILABLE FOR MAKING EMPLOYMENT PROJECTIONS IN THE DENVER SMSA

APPENDIX I-a

METHODS AVAILABLE FOR MAKING EMPLOYMENT PROJECTIONS

METHODS USED BY OTHERS

Introduction

Many attempts have been made to forecast or project employment either by industry, total employment or occupation. These attempts have been on a nation-wide, state-wide and local level. There are at least the following four types of methods of projecting employment:[1] (1) ask employers to predict their employment, (2) extrapolate historical data, (3) relate estimates of total economic activity to individual industries, (4) analyze the characteristics of demand and develop projections through statistical relationships of the factors having the greatest influence on demand. Included in the latter method are most of the so-called historical studies.

The studies surveyed as background for making the present study are described very briefly below and then described in further detail later in this report.

Insofar as feasible, the authors' words have been followed closely to help assure accuracy and clarity in summarizing their thoughts.

Brief Description

The most common employer forecasts are short-run guesses as to future total employment and employment by industry. Examples are most of the forecasts sponsored by the U. S. Bureau of Employment Security, the Employment Forecast Survey of the Canada Department of Labor, the Dun and Bradstreet survey of expectations,[2] and the Fulmer study[3] of emerging technical occupations in the Georgia Textile industry. Indiana employers have since 1949 been reporting bi-monthly to the Indiana Employment Security Division their estimates of their employment two months hence and four months hence.[4/] Illinois employers have since 1946 been reporting bi-monthly to the Illinois Department of Labor their estimates of their employment two months hence and four months hence.[5/]

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[1] There is really some overlap among the different types.

[2] See Douglas G. Hartle, The Employment Forecast Survey, Toronto, University of Toronto Press (1962), pp. 4-8, for a more lengthy description of these surveys.

[3] Research Design to Forecast Demand for New Types of Technicians in an Industry, Engineering Experiment Station, Georgia Institute of Technology, Atlanta (mimeographed).

Most State Department of Employment Security Offices are engaged in research, some continuing and some occasional, of job opportunities, along five lines. Area Skill Surveys consist of occasional requests of employers to anticipate their needs by occupation three years hence and five years hence.[6/] Job Vacancy Studies are an attempt to refine methods for determining current job vacancies.[7/] Occupational Guides describe job content and such economic factors associated with the occupation as advancement prospects, duties, etc.[8/] Occupational Index Surveys follow Area Skill Surveys and show a cross-tabulation of occupational employment and industry employment in the local area.[9/] Training Needs Surveys are in the nature of crash, current surveys to find immediate needs for trained workers in short supply.[10/]

Canadian employers have since 1946 been reporting to the Department of Labor of the Canadian government bi-monthly their estimate of employment three months

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[4/] William H. Andrews and Gene S. Booker, Forecasts of Future Labor Requirements by Indiana Employers, Indiana University, Bloomington (1958), p. 1.

[5/] Robert Ferber, Employers' Forecasts of Manpower Requirements: A Case Study, University of Illinois, Urbana (1958), p. 9.

[6/] Labor Market Research Methods, U. S. Department of Labor, Bureau of Employment Security, Washington: U. S. Government Printing Office (1957).

[7/] Employment Security Research Exchange, U. S. Department of Labor, Bureau of Employment Security, Washington: U. S. Government Printing Office (November, 1964), p. 8.

[8/] Ibid., p. 7.

[9/] Ibid., p. 4.

[10/] Ibid., p. 7.

hence and six months hence.[11] Dun and Bradstreet since 1947 have surveyed each quarter a sample of manufacturers, wholesalers, and retailers as to whether their employment will remain the same, go up, or go down during the coming quarter.[12]

Fulmer, by interviewing employers in the textile industry in Georgia, attempted to find out what new occupations were emerging in the textile industry as a result of technological change.[13]

Four studies have been made of the employers' anticipations from the Bureau of Employment Security's surveys of employers' forecasts of future labor requirements. These studies were made by Ferber,[14] Andrews and Booker,[15] Andrews,[16] and the New York State Department of Labor.[17] All of the studies indicated that employer forecasts were subject to substantial errors and were overly optimistic in predicting employment.

An example of the extrapolation of historical data is the analysis of Colorado nonagricultural employment made by Droste.[18] The major purpose of his analysis was to project nonagricultural employment to 1970.

The third method of projection usually involves relating estimates of partial or total economic activity to individual industries and then to individual occupations. Examples of this method are the San Francisco study,[19] the Ohio study,[20] the projections of the National Planning Association,[21] and the Vaughan study.[22]

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[11] Hartle, _op_. _cit_., p. 4.

[12] _Ibid_., p. 6.

[13] _Research Design to Forecast Demand for New Types of Technicians in an Industry_, _op_. _cit_.

[14] Ferber, _op_. _cit_.

[15] Andrews and Booker, _op_. _cit_.

[16] William H. Andrews, _Forecasts of Future Labor Requirements by Indiana Employers_: _Second Report_, Indiana University, Bloomington (1959).

[17] Floyd Albert, Claude Hillinger, and Samuel Baron, _Forecasts of Change in Employment Requirements_: _Four New York Labor Market Areas_, New York State Department of Labor, Division of Employment, New York (1951).

[18] Leo A. Droste, _A Least Squares Analysis of Colorado Nonfarm Employment_, Bureau of Business Research, University of Colorado, Boulder (1964).

Two studies of employment projections have been made following generally the method suggested by the Bureau of Employment Security.[23] The California Department of Employment projected the occupational needs of the San Francisco-Oakland Bay Area to 1962 and 1965, using a ratio technique.[24] Conducted by the California Department of Employment, and starting from population, it projected the labor force participation rate, assumed an unemployment rate, forecast employment by industry from Department of Employment data, constructed a 1960 matrix of occupations, and applied this occupational mix in 1962 and 1965 to the forecasted industry employment. The Ohio study's procedure was similar except that for its occupational projection, per cent distributions of Ohio employment and the occupations in the various industry divisions for 1960 and 1970 were obtained by multiplying the 1950 Ohio per cent distributions by the projected percentage changes based on the occupational industry matrix for the United States.[25]

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[19] Manpower Resources of the San Francisco-Oakland Bay Area, State of California, Department of Employment, San Francisco (1963).

[20] Manpower in Ohio, Ohio Bureau of Unemployment Compensation, Division of Research and Statistics, Columbus (1963).

[21] National Planning Association, Center for Economic Projections, National Economic Projection Series: American Industry in 1976 and 1985, Washington (1964); and Regional Economic Projection Series: State Employment Trends to 1976, Washington (1962).

[22] Robert D. Vaughan, Jobs and the Future, Mountain States Telephone Company, Denver (1962), mimeographed.

[23] For these suggestions, see Sources of Data for Manpower Projections, U. S. Department of Labor, Bureau of Employment Security, Washington: U. S. Government Printing Office (1961).

[24] Manpower Resources of the San Francisco-Oakland Bay Area, op. cit.

[25] Manpower in Ohio, op. cit.

The National Planning Association has projected the national population, labor force, employment, income, output, and productivity, and then has projected the state and regional components of these parameters.[26]

Vaughan projected employment by industry and by occupation for the Denver Standard Metropolitan Statistical Area to 1970[27] by assuming U. S. trends, evaluating Colorado trends in terms of U. S. growth, and evaluating Denver in terms of Colorado growth. Starting with population, he projected labor participation rates, assumed an unemployment rate, projected a 1950-1960 industry employment trend, and applied the 1960 occupational mix to the 1970 industry employment projections.

Several groups have approached the problem of projecting employment by analyzing the factors that influence the demand for labor and by developing statistical relationships among the more important factors.

The general approach of the United States Department of Labor has been to project the overall level of economic activity for the nation and to relate this level of activity to employment in each industry, followed by a determination of the occupational requirements in each industry, the supply of workers, and training requirements. It has employed two types of approaches in relating estimates of total economic activity to individual industries. The first approach projects employment for all industries and employment in individual industries is related to the total. The second type of approach projects total production for all industries and production in individual industries is related to the total; then projected industry production for each industry is translated into estimates of employment for each industry.

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[26] National Planning Association, op. cit.

[27] Robert D. Vaughan, op. cit. In order to report statistics for areas consisting of one county or more which are relatively densely populated and constitute a socially and economically integrated metropolitan area, the Bureau of the Budget in the Executive Office of the President formulated a concept called "standard metropolitan statistical area." A standard metropolitan statistical area is a county, or group of contiguous counties, which contains one city of at least 50,000 inhabitants, and the activities of the population of the area form an "integrated economic and social system." (See Bureau of the Budget publication, Standard Metropolitan Statistical Areas, Washington: U. S. Government Printing Office (1961), or its 1963 revision.) The definition of an individual SMSA involves two considerations: (1) a city or cities of specified population, and (2) economic and social relationships with contiguous counties which are metropolitan in character.

The Economic Growth Studies[28] of the Inter-Agency Committee consist of projecting the demand for and supply of labor by industry by using projections of population, labor participation rates, and total income and output of the economy and distributing this output among the various industries.

The Department of Labor is constructing an industry-occupational matrix[29] of the 1960 census of population data, which may be applied to the economic growth studies to determine employment by occupation in each industry for 1970 and 1975. "These projections will reflect judgments based on trend data on the changing occupational distribution of each industry shown by the 1950 and 1960 censuses, trends in production and nonproduction worker employment, the changing proportion of employment in broad occupational groups, and information on changing occupational patterns in specific sectors of the economy from a variety of statistical sources."[30]

The Occupational Outlook Handbook[31] provides current information on 700 kinds of jobs. Its forecasts are judgmental, based on interviews with persons in industry and data supplied by the research programs of BLS. The forecasts are stated in the handbook in a general manner.

Flanders and Fulton[32] of the Bureau of Labor Statistics have conducted a study on the employment outlook and changing occupational structure in electronics manufacturing by finding electronic shipment estimates for 1958-1961 and 1970, developing shipments-per-employee estimates and projections, and dividing electronic shipment estimates by shipments-per-employee to get employment totals.

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[28] For a description, see Manpower Research and Training, U. S. Department of Labor, Washington: U. S. Government Printing Office (1965), pp. 90-91.

[29] Seymour L. Wolfbein, "Manpower Projections and Techniques," Human Resources (Vol. XI), United States Papers Prepared for the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas, Washington: U. S. Government Printing Office, p. 25.

[30] Estimates of Employment Requirements by Occupation for 1970, U. S. Department of Labor, Bureau of Labor Statistics, Washington (research in progress).

[31] Occupational Outlook Handbook, U. S. Department of Labor, Bureau of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office (1963-1964 edition).

[32] Employment Outlook and Changing Occupational Structure in Electronics Manufacturing, U. S. Department of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office.

Another BLS study, by Michael and others,[33/] projected the demand for scientific and technical personnel to 1970 by analyzing the factors affecting demand for personnel in each occupation and developing their projections through statistical relationships of the factors found to have the greatest influence on these requirements.

Sugg's method[34/] involves five steps: (1) A rough first approximation of the future employment structure by economic activity is derived. (2) A detailed analysis of each important economic activity, arriving at an estimate of future employment, is made. (3) The first approximations of future employment are modified in accordance with the results of the detailed analysis of each important activity. (4) An occupational breakdown of employment in each economic activity in the future period is derived. (5) The training requirements for each important occupation are estimated.

Harms is conducting a study[35/] which is an attempt to project employment by industry and by occupation to 1970, 1975, and 1980, for Silver Bow County, Montana. His procedure is to analyze historical data for trends, project the basic trends, and then engage in a further analysis in order to gain an understanding of the forces which produced the trends, thereby obtaining a judgment about the likelihood of the persistence of those trends. Key industries are identified by use of location quotients, and weights are given to each of eleven industry groups to produce modification of trends of employment. Occupational-employment projections will be made by projecting trends of employment by occupation by industry, and qualifying the projections by an analysis of the factors affecting the employment by industry.

[33/] The Long-Range Demand for Scientific and Technical Personnel, U. S. Department of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office.

[34/] The Forecasting of Manpower Requirements, U. S. Department of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office (1963).

[35/] To Develop A Model or Models for Projecting Employment by Industry and by Occupation for Counties, Labor Market Areas, or SMSA's Together With Appropriate Data, Philadelphia, Temple University, Office of Automation and Manpower Research, Office of Manpower, Automation and Training (in process).

The most important historical studies which are helpful in making occupational projections for the Denver economy are the studies by Arrington,[36] the Denver Research Institute,[37] and the Governor of Colorado's Tax Study Group.[38]

Arrington examined statistical data in the decennial census reports, determined location quotients, and described the economic development of the Mountain West in an attempt to gain some insight into the direction in which the economy was going.

The Governor's Tax Study Group described the expansion paths of Colorado, calculated indexes of Colorado industrial specialization, and made qualitative predictions of employment by broad industry group.

The study of Colorado by the Denver Research Institute is primarily historical, but an attempt was made to build up to total employment by making individual industry projections of employment to 1970. The projections were made on the basis of projected output, opinions of experts in each industry, and by utilizing trend ratios of output between Colorado and the nation.

The Public Service Company of Colorado,[39] predicted the paths of development in Colorado, based upon the Denver Research Institute study.

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[36] Leonard J. Arrington, The Changing Structure of the Mountain West, 1850-1950, Logan: Utah State University Press (1963).

[37] James F. Mahar, Dean C. Coddington and John S. Gilmore, Economic Forces Behind Colorado's Growth, 1870-1962, with Projections to 1970, Prepared for Colorado State Department of Employment Resources and Community Development Division: Denver (February, 1963).

[38] Financing Government in Colorado, Report of the Governor's Tax Study Group, State of Colorado: Denver (1959).

[39] An Analysis of Colorado's Economy With Projections to 1970, Public Service Company of Colorado, The Area Development Department, Denver.

DESCRIPTION IN DETAIL

Employer Forecasts

The most common employer forecasts are short-run guesses as to total employment and employment by industry. Examples are the estimates of future employment made by employers in Indiana and Illinois and the Employment Forecast Survey of the Canadian Department of Labour. Andrews and Booker in 1958 evaluated the accuracy of the bi-monthly employment forecasts of 1,000 Indiana employers; and Andrews made a further analysis in 1949. Ferber made the same sort of analysis of the forecasts of Indiana employers. Hartle investigated the Employment Forecast Survey of the Canadian Department of Labour.

Andrews and Booker[40]

Andrews and Booker, in 1958, evaluated the accuracy of the bi-monthly employment forecasts of more than 1,000 Indiana employers who had been reporting since 1959 to the Indiana Employment Security Division their estimates of future employment in their establishments.

One hundred thirty sample firms were selected for their study. A basic work sheet was prepared on which were recorded employment data for one year ago, four months ago, two months ago, one month ago, current, two months hence, and four months hence. Estimated and actual changes in employment were compared according to the direction-of-change forecast and the relative-amount-of-change forecast. Fifty-eight per cent of the 130 firms forecast no change in the direction-of-change in the two-month estimates at least one-half of the time, and their accuracy was only one-third as great as those firms forecasting increases or decreases in employment. When the employment data were totaled by industry and area, the accuracy of estimates on direction-of-change was noticeably improved. The large firms forecasted less accurately the direction-of-change than the small firms. Whether the performance on direction-of-change can be evaluated as satisfactory or not, however, depends on the standards adopted. For the whole sample of 130 firms, uniform projections of current level would have done almost as well as the forecasts made. Only 11 of the 130 firms forecasted with outstanding accuracy.

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[40] Andrews and Booker, *op. cit.*

Andrews and Booker tentatively concluded that only about one-fourth of the firms were making an actual effort to forecast and were estimating employment changes better than could be done by a straight projection of current employment.

The 4-month estimate data were distinctly inferior to 2-month estimates when measured by mean and median percentage error. Therefore, to investigate further, 54 of the original establishments were selected for visitation.

Functionally, it was found that the positions held by the persons actually preparing the forecasts could be classified as personnel (63%), accounting (22%), production (6%), store or office manager, etc. (9%). The group classified as accountants forecasted the most accurately. The forecaster's level of authority had little to do with the accuracy of the forecasts. Having access to current information did not appear to make the forecasts any more accurate. Reasons given for error included being a branch plant, subject to changes from the central office, being a jobber with unstable orders, general market instability, labor disputes, and cancellation of contracts. In the interview sample of 54 firms, only eight showed up fairly well on the direction-of-change and were comparatively low on the number of no-change estimates. The main reason given for the success of these eight firms was that the forecasters had fairly complete information and were taking the forecasts seriously. Also, good relations seemed to exist between local office personnel and employer representatives.

Andrews[41]

Andrews, in a further analysis of the estimates of future labor requirements by Indiana employers, suggested that, for the individual firm data, the direction-of-change aspects of the estimates may be more important than was concluded from the first report, especially if the individual firm data can be summarized effectively in diffusion indexes; and that the 4-month estimates may be more reliable and potentially valuable than they at first were thought to be. With respect to the various employment totals, the direction-of-change estimates were raised to an average of 50% for both the 2 and 4-month periods, as compared to around 40% for the individual firm estimates. He concluded that the estimates achieved somewhat better results than straight projection of current employment.

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[41] Andrews, op. cit.

In observing the employment totals for five selected geographical areas, there was further indication that the employer forecasts were doing better than a straight projection of the current employment level. The forecasters predicted upturns more often than downturns; and underestimated employment on the upturns and overestimated employment on the downturns.

A diffusion index was used, showing the per cent of estimates which were higher than current actual employment. The accuracy of the diffusion indexes on direction-of-change was approximately the same magnitude as the average accuracy on direction-of-change observed for the individual firm estimates that involved some change.

Andrews concluded that some firms are forecasting better than others, either because of greater effort or greater skill on the part of the forecasters, or because certain characteristics of the firm and industry make it more favorable for forecasting, the notable characteristic being the normal degree of employment stability present. He suggested that the estimates would be more reliable and more useful if employers would indicate changes where changes might possibly occur rather than projecting current employment.

Ferber[42]

Ferber attempted to secure data on expectations of the business community and to examine how this information could be used in economic analysis and forecasting. He wanted to see how individual firms in the bi-monthly report of Illinois employers to the Illinois Department of Labor made their forecasts of their labor force two months in advance and four months in advance and how the accuracies of the different methods compared with each other. He further wanted to find to what extent the anticipations of individual firms, and the structure of these anticipations, were related to those of the industry as a whole.

In the reports to the Illinois Department of Labor, cooperation of all business firms in the Chicago area with 65 or more workers was requested. This sample accounted for about 80% of all manufacturing employment in the area.

Most of the analysis of Ferber's study was carried out for 59 firms in 14 industries in the Chicago-Calumet Labor Market Area. The accuracy of the anticipations was largely independent of the manner in which the employers' anticipations were prepared. On the average, the individual firms came within about 5% of actual employment on their 2-month estimates and 7% of actual employment on the 4-month anticipations. Substantial variations in accuracy were evident by industry. The errors were much higher on the downswings than on the upswings. Errors tended to be lowest when conditions were relatively stable. The average error of the anticipations on an industry-wide basis was considerably less than the corresponding average of individual firms' errors. Industries with high average errors of individual firm anticipations also tend to have the highest errors of anticipation on an industry-wide basis. There is some indication that differences in the errors of anticipations of individual firms are related to magnitude of employment changes, the extent of cyclical variation in the industry, and the use of mechanical extrapolation of level. Only a small fraction of the firms was able to anticipate direction of changes in employment better than chance.

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[42] Ferber, op. cit.

Considering the structure of the anticipations, 70% of the firms use as their 4-month projection the same anticipation reported for two months ahead. About half of the firms obtain their 2-month anticipation by extrapolation of recent levels.

The accuracy of the anticipations of many of the firms is quite high. The "optimism hypothesis" advanced in connection with the analysis of the railroad shippers' forecasts is supported.[43]

We might conclude from this study that we cannot necessarily depend on corporate officials for help, because personnel departments are optimistic in their anticipations because they want to justify their existence. In this connection, two things must be noted: The turnover rate is from 2 to 7 per cent. Therefore, "new" employees are processed by personnel at this rate. The other thing which should be especially noted is the optimism hypothesis. The errors of anticipations on an industry-wide basis is considerably less than the average for the individual firms' errors. Ferber says this is because errors are cancelled out as one goes from firms to industry. Fishman[44] says that errors could become exaggerated as one aggregates, because when the factors exist for things to go bad for one firm, they exist for things to go bad for the other firms, as a rule.

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[43] Ibid., p. 26.

[44] Leslie Fishman, Professor of Economics, University of Colorado.

Hartle[45]

Hartle investigated the Employment Forecast Survey of the Canadian Department of Labour. In the survey, a stable sample of approximately 800 establishments was selected. Each establishment was asked to report its actual employment on the three preceding months, and forecast the employment of the establishment three months in the future and six months in the future. The questionnaires were forwarded to the sample establishments four times each year.

The actual employment and the forecast employment of the sample establishments drawn from each component of the industrial classification were aggregated separately for each component. The published Dominion Bureau of Statistics index for each component that applied to a preceding month was projected to the future target date by the ratio of the aggregate forecast employment of the sample establishments at the target date to the aggregate actual employment of the same establishments on the corresponding preceding month. The predictions for groups of industrial components were derived from the weighted ratios of the individual components.

Hartle attempted to (1) assess the importance of the sampling problem as distinct from the forecast problem, (2) evaluate the accuracy of the respondents in forecasting the direction of nonseasonal employment changes, and (3) determine how adequate were the forecasts submitted by individual establishments as compared with the derivation of establishment predictions by alternative techniques.

The general implications of his study were that (1) the industry predictions derived from the Employment Forecast Survey were unreliable, (2) most of the establishments submitted forecasts with no predictive value, (3) there is probably no single explanation of these errors, and (4) information about employers' expectations could be used as one variable in a larger model, whether formal or informal, from which employment predictions might be derived.

Albert, Hillinger, and Baron[46]

The findings of the New York State Department of Labor study were consistent with the Andrews and Booker study. Like Andrews and Booker, the New York study found that there was a correlation between employment stability and size of firm, and that "stability, not size, is the most important factor influencing error . . . There is no significant variation between firms of different sizes but of equal employment stability."[47] The New York study indicated no correlation between the number of no-change forecasts submitted by the firm and the average forecast error of the firm. Clerks and technicians submitted the best 2-month forecasts. Company officials submitted better 4-month forecasts. Forecasts originating in personnel departments did not do so well as forecasts from other departments. Forecasts submitted by mail were more accurate than those obtained by telephone.

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[45] Hartle, *op. cit.*

[46] Albert, Hillinger, and Baron, *op. cit.*

Job Opportunities Research of the State Employment Security Offices

"Occupational labor market research consists of analysis of demand-supply factors in a particular occupation or group of occupations."[48] The states have been engaged in job opportunities research in five categories: (1) Area Skill Surveys, (2) Job Vacancy Studies, (3) Occupational Guides, (4) Occupational Index Surveys, and (5) Training Needs.

Area Skill Surveys[49]

One hundred twenty-six Area Skill Surveys, initiated in 1957 and completed by 44 states by March 31, 1964, provide data collected mostly from employers, on (1) the occupational composition of current employment, by sex and by broad age intervals (for estimates of replacement needs arising from deaths and retirements), (2) employment requirements by occupation for future periods -- usually two and five years hence, (3) apprenticeship and other training programs and number of workers in training, (4) interest in the need for pre-employment or supplementary vocational training, and (5) the current demand-supply situation by occupation. According to Employment Security Research Exchange,[50] in areas of current and long-term anticipated skill shortages, the data in these surveys (1) indicate the occupations in which training is needed, (2) provide the basis for counseling applicants as to job opportunities, and (3) indicate sources of labor reserves for specific recruitment.

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[47] Ibid., p. 11.

[48] Labor Market Research Methods, op. cit., p. 1.

[49] Ibid., pp. 5-39.

[50] Employment Security Research Exchange, op. cit., p. 4.

There are several possible criteria for selecting occupations to be studied. Consideration may be given to surplus and shortage occupations in the area. Significant occupations (in terms of their numerical importance in the area or in terms of those dominating the major industries) in the area which require more than casual on-the-job training may be selected. Future demand occupations determined from knowledge of expansion plans of existing industries and of the nature of proposed plants may be chosen. There may be other occupations which may be small but are a particular problem or are of a particular interest in the area. The local demand for occupations in which many applicants express a continuing interest could be verified in order to provide more realistic counseling and interviewing information. Occupations which are important to national defense and important entry occupations may also be selected.

According to the instructions in the Labor Market Research Methods, "Although all occupations in the entire nonagricultural labor force in the area may come within the scope of the study, in most areas (particularly the larger ones), emphasis should normally be directed to occupations requiring considerable training time -- perhaps one year or more."[51] It further states that the following basic information needed for an Area Skill Survey should be obtained directly from employers:[52]

1. Total current employment in the establishment.
2. Total employment requirements.
3. Scheduled hours of work per week for the majority of workers.
4. For each occupation selected for the survey:
    a. Total current employment.
    b. Trainees currently on organized training programs.
    c. Current job vacancies for which workers are presently being recruited.
    d. Number of additional workers which will be required.
    e. Number of workers expected to complete in-plant training programs.

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[51] Labor Market Research Methods, op. cit., p. 5.

[52] Ibid., p. 9.

5. Wage data may be collected for all occupations for selected occupations.
6. Information about the following subjects can prove useful:
    a. Plant expansion projects during the next 5 years.
    b. Expected shifts in industrial activity over the same period.
    c. Specific managerial, engineering, scientific, or technical occupations in which a higher or lower proportion of workers will be needed.
    d. Occupations for which the employer has experienced difficulty in hiring qualified workers during the past year and causes of such difficulties.
    e. Projected expansion of the employer's in-plant training programs.
    f. Suggestions or recommendations as to the type of occupational training programs needed most in the area.

The industries in which the selected occupations are usually found can be determined by consulting 1950 U. S. Census of Population, Occupation by Industry Special Report[53] and Volume II of the Dictionary of Occupational Titles.[54]

The analysis of occupational requirements should be based on "(1) data received from employers on the number of additional workers that will be needed because of contemplated expansion of industrial activities, (2) calculations of the number of workers that will be needed in each occupation to replace separations caused by deaths and retirements, (3) estimates of staffing needs for new industries expected to begin operations within the area if this information can be developed, and (4) total additional requirements which represent the sum of the above."[55]

The tabulation of the survey data will show the total occupational employment, requirements, and training data distributed by industry, and the total current employment and total future requirements, by industry. This should provide data for a present, two-years-hence, and five-years-hence, occupational-industry matrix of the local area.[56]

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[53] U. S. Census of Population 1950, Occupation by Industry Special Report P-E, No. 1-c, U. S. Department of Commerce, Bureau of the Census, Washington: U. S. Government Printing Office.

[54] Dictionary of Occupational Titles, (Vol. II), U. S. Department of Labor, Bureau of Employment Security, Washington: U. S. Government Printing Office (1949), pp. 507-739.

[55] Labor Market Research Methods, op. cit., p. 35.

[56] Ibid., pp. 20-24.

Total estimates of future demand for workers in the surveyed occupations can be obtained by adding the estimates of replacement needs to the estimated expansion needs indicated in the tabulations. The expansion needs are found in the two and five-year estimates of required employment. Replacement needs may be calculated by applying labor force separation rates to the estimates of employment by age group for each of the surveyed occupations. The procedure for estimating the number of separations of male workers assumes no significant differences between death and retirement rates among workers in different occupations. Where retirement policies are significant in area employment patterns, they must be provided for by modification of the separation rates included in working-life-table death rates (i.e., separations from the population). Differences in the overall per cent separations between occupations will depend on differences in the age distributions within the specific occupations. Unless the analyst has good reason to believe that a particular occupation's deaths and retirements differ considerably from the national pattern, these rates should be adequate to measure the replacement needs for a specific occupation.

Female labor force participation is generally characterized by a number of long-term separations and subsequent re-entries into the work force among all age groups, the younger as well as the older. Therefore, the separation rates for women are different than for men and can be obtained from tables of working life for women.[57] Similar information can be obtained from tables of working life for women on estimated annual accession rates from total female population to the female labor force.

To estimate the supply of trained manpower that will be available for the surveyed occupations by the end of a given period, it is necessary to estimate the number of entrants into these occupations during the period. The number of inplant trainees that are expected to complete training in two and five years, provides the base for this estimate. These figures must be supplemented, however, to include additional entrants into these occupations from sources outside the inplant training programs. This measure can best be arrived at by obtaining from local school authorities, State and local apprenticeship councils, and trade unions, their count as to the number of persons expected to complete training for the relevant occupations by the end of the period. In addition, those persons currently unemployed in specific occupations should also be included.

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[57] For example, Tables of Working Life for Women, 1950, U. S. Department of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office; or "Tables of Working Life for Women, 1950," Monthly Labor Review, (Vol. 79, Nos. 6, 8, and 10) U. S. Department of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office (June, August, October, 1956).

An Example of an Area Skill Survey[58]

An Area Skill Survey, named a job opportunity study, of the Denver Standard Metropolitan Area was undertaken during the summer of 1958. Not covered in the survey were: (1) self-employed persons, (2) unemployed workers, and (3) workers in establishments with less than four employees, who are not covered by the Colorado Unemployment Compensation Program. The survey included establishments in agricultural services; manufacturing; construction; transportation, communications and utilities; wholesale and retail trade; finance, insurance and real estate; business services, personal services, medical and professional services; government; and mining. An IBM listing of these establishments was made up, ranked by number of employees, for each of the 300 industrial classifications under the Standard Industrial Classification Manual.[59]

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[58] Planning for Tomorrow, Colorado Department of Employment, Employment Service Division, Denver (1958).

[59] The 1957 Standard Industrial Classification Manual (Bureau of the Budget) presented "a revision of the 1945 edition of Manufacturing Industries and the 1949 edition of Nonmanufacturing Industries." In the manual, "Where a single physical location encompasses two or more distinct and separate economic activities for which different industrial classification codes seem applicable, such activities should be treated as separate establishments and classified in separate industries, provided it is determined that: (1) such activities are not ordinarily associated with one another at common physical locations; (2) no one industry description in the Standard Industrial Classification includes such combined activities; (3) the employment in each such economic activity is significant; and (4) reports can be prepared on the number of employees, their wages and salaries, and other establishment type data.

"Each establishment is assigned an industry code on the basis of its major activity, which is determined by the product or group of products produced or handled, or services rendered. The structure of the Classification makes it possible to classify establishments by industry on either a two digit, a three digit, or a four digit basis, according to the degree of detail in information which may be needed."

There are ten industry divisions: Agriculture-forestry-and fisheries, mining, contract construction, manufacturing, transportation-communication-electric-gas-and sanitary services, wholesale and retail trade, finance-insurance-and-real-estate, services, government, and nonclassifiable establishments. The division

It was estimated that 25,000 additional workers would be needed in two years (1960), and 50,000 workers in five years (1963). It pointed out that the future manpower problem will vary among industries, tempered by such factors as the nature of the expansion program, diversified operations, the impact of automated and electronic developments and the establishment of new industries in this area competing for the same type of skilled workers. In order to reveal occupational opportunities for beginning workers, the questionnaire was designed with two check columns in which the employer might indicate for each payroll job listed, (1) if it was an entry job and (2) if it was a shortage job.

The report also showed sample analyses of the different industries.

In connection with the area skill survey, an occupational index, or inventory, was tabulated and distributed.[60/] This catalogue of occupations comprises 2,270 different jobs existing in the 4-county metropolitan area disclosed in the area skill survey, and discloses the occupations of 247,632 workers (all of those covered by unemployment compensation). Incorporated in the inventory is a projection, based on estimates by participating firms, of the increased numbers of workers that will be required in 1960 and 1963.

Job Vacancy Studies[61/]

A program for collecting area job vacancy information is under consideration and pilot projects are being initiated. During the 6-month period ending March 31, 1964, the Illinois Division of Placement and Unemployment Compensation completed a

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constitutes the first digit. In each division, there is at least one major group, referred to as a 2-digit industry. For example, in agriculture, forestry, and fisheries, there are commercial farms (01), noncommercial farms (02), agricultural services and hunting and trapping (07), forestry (08), and fisheries (09). In each major group, there may be one or more 3-digit industries. For example, in the major group of commercial farms, there are field crop farms (011); fruit, tree nut, and vegetable farms (012); livestock farms (013); general farms (014); and miscellaneous commercial farms (019). In each 3-digit industry, there may be one or more 4-digit industries. For example, in the 3-digit industry, field crop farms, there are cotton farms (0112), cash grain farms (0113), and field crop farms, not elsewhere classified (0119).

[60/] *Occupational Inventory*, Colorado Department of Employment, Employment Service Division, Denver (1959).

[61/] *Employment Security Research Exchange*, *op. cit.*, p. 8.

pilot study which indicated the feasibility of collecting job vacancy information by occupation for the Chicago area.

The job vacancy studies are to be a joint BES-BLS project, the results of which will be used to implement a full-scale job vacancy program in fiscal 1966 for 150 labor areas if resources are made available.

About one year ago, the National Industrial Conference Board began a study of the feasibility of collecting job vacancy statistics.[62] The following is a summary of the first findings of this study which took place in the Rochester, New York, area. Every branch of industry was covered with the exception of agriculture and private households.

The National Industrial Conference Board found that there were nearly 8,000 job vacancies in Monroe County on February 12, 1965. The vacancy rate varied considerably between industries, with higher rates in construction, auto dealers, service stations, and education. Professional, semiskilled and skilled occupations were most in demand.

The survey also found that the occupation title is often inadequate in describing a job or job opening. More information is needed, such as the minimum years of education and experience desired by the employer. Many job vacancies were available to persons who had not graduated from high school, although one-fourth of all vacancies required at least four years of college.

In comparison with the unfilled job openings in the files of the offices of the United States Employment Service, the NICB survey estimated a total number of vacancies almost five times the number in the State file. However, the per cent distributions by occupation group did not differ greatly (Table 1).

Myers concluded that the experience of the NICB with these surveys has led them "to the tentative conclusion that the collection of job vacancy statistics is a feasible operation when the information is obtained by interview and the ground work in the community has been carefully prepared."[63]

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[62] "Can You Measure Job Vacancies?" The Conference Board Record, National Industrial Conference Board, Inc.: New York (May, 1965), pp. 50-59.

[63] *Ibid.*, p. 59.

TABLE 1

COMPARISON OF NEW YORK STATE EMPLOYMENT SERVICE JOB OPENINGS WITH NICB SURVEY JOB OPENINGS, ROCHESTER SMSA

Occupation group	N. Y. State Employment Service, job openings		NICB Survey, estimated vacancies	
	Number	Per cent of total	Number	Per cent of total
Professional, semiprofessional, and managerial workers	447	27.8	2,644	33.1
Clerical and sales workers	314	19.5	1,154	14.4
Service workers	379	23.5	563	7.0
Skilled workers	248	15.4	1,393	17.4
Semiskilled workers	145	9.0	1,730	21.6
Unskilled workers	74	4.6	507	6.3
Total	1,607	100.0	7,991	100.0

Source: The Conference Board Record, National Industrial Conference Board (May, 1965), p. 57.

Occupational Guides[64]

An occupational guide contains basic information designed to give job-seekers and counselors a picture of the job content and economic factors associated with the occupation. It describes the duties of the employee, the educational and experience requirements, advancement prospects, wages, working conditions, employment outlook, and other important facts associated with various occupations. The Minnesota Department of Employment Security has prepared a report as a result of a study to determine methods and techniques that should be utilized in the preparation of vocational or guidance information on a local area level.[65/]

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[64] Employment Security Research Exchange, op. cit., p. 7.

Occupational Indexes[66/]

An Area Occupational Index is designed to show the full array of occupations within a given area, and employment by industry for each of the occupations. When all of the occupations in the area are surveyed, a comparison with the broad occupational groups reported in the decennial census may be desirable. Table 2 shows how the decennial census can be compared with the DOT[67/] groupings. The arrows show the areas of comparability. A more detailed description of the comparison might be obtained on a loan basis from Mr. Carl A. Heinz, Chief, Division of Technical Development, Bureau of Employment Security, U. S. Department of Labor, Washington, D. C., 20210.

Training Needs Surveys[68/]

Training Needs Surveys are abbreviated skill surveys. They estimate supply and demand by occupation for shortage occupations over a 6-month, 1-year, or 2-year period. Training needs surveys, in most instances, are prepared for internal use only and are not published or made available for general release. During the 6-month period ending March 31, 1964, ten states completed training needs surveys.

Fulmer[69/]

Fulmer was primarily interested in designing a method to forecast the demand for new technicians, by determining the dominant trends in technology for an industry and establishing the relationship of technological problems to problem-solving through employment of specific technical skills.

[65/] Occupational Information Study, Minnesota Department of Employment Security: St. Paul.

[66/] Labor Market Research Methods, op. cit., pp. 40-44. See also Occupational Labor Market Index, Iowa Employment Security Commission: Des Moines.

[67/] Dictionary of Occupational Titles, op. cit.

[68/] Employment Security Research Exchange, op. cit., p. 7.

[69/] Research Design to Forecast Demand for New Types of Technicians in an Industry, op. cit., p. 5.

TABLE 2

CENSUS OCCUPATIONAL CLASSIFICATION COMPARED WITH DOT GROUPINGS

	Census classification	DOT classification	
1.	Professional, technical, and kindred	0-0 thru 0-6 except 0-43	Professional, semiprofessional
2.	Farmers and farm managers	3-0 thru 3-9 3-37 (part) 3-38	Agricultural, fishery, forestry, and kindred
3.	Managers, officials, and proprietors, except farm	0-7 thru 0-9 except 0-81	Managerial and official
4.	Clerical and kindred	0-81, 1-0 thru 1-4, 1-57 (part)	Clerical and kindred
5.	Sales workers	1-5 thru 1-9 except part of 1-57	Sales and kindred
6.	Craftsmen, foremen, and kindred	0-43, 4-1, 4-7, 4-16, 4-21, 4-26, 4-29, 4-32, 4-35, 4-38, 4-44 thru 4-49, 4-60, 4-68, 4-71, 4-73, 4-75, 4-76, 4-80, 4-81, 4-83, 4-84, 4-86, 4-95, 4-97, 5-05, 5-08, 5-09, 5-12, 5-17, 5-23 thru 5-32, 5-41, 5-42, 5-53, 5-55, 5-72, 5-73, 5-76 thru 5-83, 5-88, 5-91 thru 5-99, 6-07, 6-29, 6-35, 6-44, 6-73, 6-81, 6-83, 6-84, 6-86, 6-97, 7-08, 7-17, 7-23, 7-24, 7-26, 7-27, 7-31, 7-53, 7-55, 7-59, 7-72, 7-73, 7-76, 7-77, 7-79, 7-81, 7-83.	
7.	Operatives and kindred	All the DOT 4's and 5's that are not included under craftsmen, foremen, and kindred; all the DOT 6's and 7's that are not included under craftsmen, foremen, and kindred and laborers, except farm and mine; and 9-16, 9-20, 9-22, 9-35, 9-48, 9-57, 9-71, 9-73, 9-86, 9-87, 2-47, 3-30, 3-9.	
8.	Private household workers	2-0	Domestic service occupations
9.	Service workers, except private household	2-2 thru 2-9 except 2-47 and 2-68	Service workers, except private household
10.	Farm laborers and foremen	3-11 thru 3-19, 3-37 (part)	Agricultural, fishery, forestry, and kindred
11.	Laborers, except farm and mine	3-40, 3-8, 6-30, 7-37, 7-47, 7-85; all DOT 8's; all DOT 9's except those listed under operatives and kindred.	

Source: Labor Market Research Methods, U. S. Department of Labor, Bureau of Employment Security.

The method of forecasting was done by personal interviews with top technical personnel and questionnaire survey to a larger representative sample of firms. A questionnaire was used in the Georgia Skill Study to detect and define the new technicians that were evolving in the textile industry in the state.

Fulmer found through a field investigation of the problem that response rates from personal interviews were better than response rates from letters. In his sample of firms, he used 100 employees as a cut-off. He maintained that, for a textile industry no larger than 276 establishments, a 100% census of all establishments of 100 or more employees was necessary, because there were so few new technical occupations in the industry. "Because of the high cost of such a survey relative to the expected results, it was determined that this approach would not be tested further."[70]

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[70] Manpower Research and Training, U. S. Department of Labor, Washington: U. S. Government Printing Office (1965), p. 86.

EXTRAPOLATION

Droste[71]

In his linear extrapolations of nonagricultural employment in Colorado to 1970 by major industrial classifications, Droste used Bureau of Labor Statistics annual averages, as reported. His report presents "nonfarm" employment projections by year to 1970, by major-group industry classification. His most general conclusion is that "Total nonfarm employment should continue to grow, reaching an estimated 643,000 jobs by 1970."[72] The report contains tables showing, from 1939 to 1963, annual per cent change in Colorado and United States population, total personal income, per capita personal income, nonfarm employment, and the annual employment trend of total Colorado nonfarm employment and of the major industrial categories.

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[71] Leo A. Droste, op. cit.

[72] Ibid., p. 8.

COMPONENTS AND RATIOS

San Francisco Study[73]

The California Department of Employment projected the occupational needs of the San Francisco-Oakland Bay Area to 1962 and 1965. Total population for the SMSA projected to the target dates by the California Department of Finance was used as the base for this study. Labor force participation rates, based on the 1960 Census of Population, were projected and adjusted in line with the anticipated national and state labor force trends. Estimates of the labor force were obtained by applying the appropriate labor force participation rate to the specific age and sex group.

Projections of total civilian employment were made by subtracting five per cent of the civilian labor force, which is the projected unemployment rate, from the civilian labor force.

Forecasts of employment by industry were based on monthly estimates of employment by industry prepared by the Department of Employment and the Department of Industrial Relations. The forecasts were made for each 2-digit industry; and, in some cases, for each 3-digit industry. They were based on an analysis of past trends and an evaluation of factors which influence employment levels in each industry.

The estimates to 1965 were adjusted to match Census-type industry definitions. The Census definitions are generally comparable to the standard industrial classification. In Census data, government workers are apportioned among the industries in the private sector in which the work in which they are normally engaged is carried on. For example, employees of government hospitals are put in the medical service industry and employees of naval shipyards are put in the transportation equipment industry. The only government workers in "Public Administration" are the employees of the legislative, executive, and judicial branches of government. In the standard industrial classification, all government workers are included in a single industry division called "Government."

The occupational projections are developed from an Industry-Occupational matrix, constructed from data published in the 1960 Census of Population and derived from an evaluation of the occupational composition of local industries.

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[73] Manpower Resources of the San Francisco-Oakland Bay Area, op. cit.

The occupational ratios which were developed in the matrix were applied to the Census-type estimates of annual average employment by industry for 1960, 1962, and 1965.

The influence of technological advances, growth in size and complexity of component firms, and changes in the occupational composition of the industry, upon occupational patterns in each industry was considered insofar as information concerning these forces was available. Then the estimates for 1962 and 1965 were adjusted in line with past occupational trends.

The Ohio Study[74/]

The Ohio Bureau of Unemployment Compensation projected Ohio population, labor force, and employment by industries and occupations to 1970. The methods used in most cases were those suggested in the Handbook on Sources of Data for Manpower Projections.[75/] The method used to obtain projections of the population for 1965 and 1970 was the component method. Ohio civilian labor force projections, by sex and age group, were obtained by applying labor force participation rates to the projected civilian population data.

The 1960 nonagricultural wage and salary industry employment estimate was developed by multiplying the April 1960 Ohio Current Employment Statistics by the ratio of the 1950 adjusted Census estimate to the 1950 Ohio Current Employment Statistics estimate. In order to project the broad industry components (agricultural, nonagricultural wage and salary, and nonagricultural "all other") of employment of 1970, it was assumed that the 1950 to 1960 trend in the proportions in each component would continue to 1970.

For employment by occupations, the 1950 U. S. occupational distribution of employment by industry was obtained from the 1950 Census of Population. Estimates and projections for 1960 and 1970 were based on the assumption that occupational patterns for 1960 and 1970 in Ohio did and would, follow national trends. Per cent distributions of Ohio employment in the occupations in the various industry divisions for 1960 and 1970 were obtained by multiplying the 1950 Ohio per cent distributions by the projected percentage changes based on the occupational-industry matrix for the United States.

[74/] Manpower in Ohio, op. cit.

[75/] Handbook on Sources of Data for Manpower Projections, U. S. Department of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office (1961).

The National Planning Association[76]

The National Planning Association in its National Economic Projection Series gives historical statistical data on population, labor force, employment, income, output, and productivity and projects these parameters for the nation to various selected years. In its Regional Economic Projection Series, it does this for states and regions.

At the national level, its study disaggregates the economy into 107 groupings of industries and projects employment at three different levels of disaggregation.

The employment measure is the total number of persons employed as given for the major economic sectors in the Bureau of the Census monthly survey of households, published as the Monthly Report on the Labor Force.[77] This household data refers to the number of persons employed. Data on the number of jobs held by wage and salary workers are obtained from the historical statistics of the Bureau of Labor Statistics, published in Employment and Earnings.[78] Data on self-employed persons comes from National Income Numbers of the Survey of Current Business.[79] The household data are distributed to the 2-digit and 3-digit industries in proportion to the number of jobs held by wage and salary employees. Data on self-employed persons were not estimated by the Bureau of Labor Statistics for some years prior to 1958. For these years, employment estimates are based on (1) the employment data reported by the Bureau of the Census in the Annual Survey of Manufactures[80] as shown in the various issues covering the period 1947-57, (2) the 1958 Census of Manufactures,[81] and (3) data that the

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[76] See especially American Industry in 1976 and 1985, National Planning Association, Washington (1964), pp. 177-180.

[77] Monthly Report on the Labor Force, U. S. Department of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office (continuing series).

[78] Employment and Earnings, U. S. Department of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office (continuing series).

[79] Survey of Current Business, U. S. Department of Commerce, Office of Business Economics, Washington: U. S. Government Printing Office.

[80] Annual Survey of Manufactures, U. S. Department of Commerce, Bureau of the Census, Washington: U. S. Government Printing Office.

[81] 1958 Census of Manufactures, U. S. Department of Commerce, Bureau of the Census, Washington: U. S. Government Printing Office.

Bureau of Employment has published in annual statistical supplements to Employment and Wages Covered by State Unemployment Insurance Laws[82] for the period 1947-58.

Employment in gas utilities is estimated from the data provided by the American Gas Association in Gas Facts.[83] Government enterprise employment in utilities is allocated among 3-digit utilities on the basis of data reported by the 1957 Census of Governments.[84] Further details of its employment data construction can be found in its publication, American Industry in 1976 and 1985: Projections of Output, Employment, and Productivity.[85]

In its state projections, the National Planning Association assumes that the national economy is the logical place at which to start, that over the long-run, population tends to follow employment opportunities, and that employment is an indicator of a region's capacity to produce. It, therefore, begins its projections by examining the state components of national employment, determining the ratio of state total employment and industrial sector employment to national total employment and industrial sector employment, over time. It assumes that export employment is the key generator for state growth and that population movement will respond to the location of industrial activity. Although industry tends to move to areas in which it can sell its products and in which it can attract a suitable work force, the National Planning Association assumes that people are more mobile than industry and that people migrate mainly because of job opportunities.

Distribution of employment among industries within a state will change because this distribution is changing nationally, but it will also change because each state shares differently in the national growth or decline of each industry.

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[82] Employment and Wages of Workers Covered by State Unemployment Insurance Laws by Industry and State, U. S. Department of Labor, Bureau of Employment Security, Washington: U. S. Government Printing Office.

[83] American Gas Association, Gas Facts, Washington: American Gas Association, Bureau of Statistics (1952), Table 190, p. 250, and (1961), Table 203, p. 222.

[84] 1957 Census of Governments, U. S. Department of Commerce, Bureau of the Census, Washington: U. S. Government Printing Office.

[85] American Industry in 1976 and 1985: Projections of Output, Employment and Productivity, op. cit.

Its technique for state employment projections can be summarized in the following three steps: (1) Divide up the national growth of each industry among the states by weighing the comparative advantages of the states. (2) Project export employment. (3) Derive from export employment levels the estimate of residentiary employment and population.

In its state projections, it compares the actual employment changes with the employment changes which would have occurred had all regions shared in growth equally.

The regional projections are obtained by aggregating the state projections in each region.

Vaughan[86]

Vaughan projected employment by industry, by occupation and by sex for the Denver Metropolitan Statistical Area to 1970. The general approach in all of his projections was to proceed from the whole to the parts. Basic assumptions were established regarding U. S. economic and social trends. Colorado trends were evaluated in terms of U. S. growth. Denver area growth was related to Colorado growth. General population, employment and income projections for Denver were then broken down into the component parts. Figuring prominently in this system is the ratio method. This is the relationship which a component of population, employment, income, etc., bears to the total.

The assumptions underlying the Census Bureau's Series II projections (1958) were adopted for the Colorado and Denver area projections. Fertility was assumed to approximate the 1955-57 level throughout the projection period. The death rate was expected to stay the same or perhaps edge downward from the 1950-1960 experience. Net immigration during the 1960's was expected to be slightly below that of the 1950's because of lessened military manpower requirements in the area and because allowance could not be made in the projections for another industry the size of the Martin-Marietta Company. Annual projections by selected age groups took into consideration the effect of immigration and cohort survival over the period.

For the most part, projections of occupational components represented a continuation of trends noted in the 1950's.

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[86] Vaughan, op. cit.

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[86] Vaughan, *op. cit.*

Starting from a 1960 base of employment, Vaughan made assumptions regarding withdrawals from the labor force during the 1960's because of retirement, death, marriage, child-bearing, etc. All employed persons who were 65 years and over in 1960 were withdrawn. Also withdrawn were about half of those in the 55-65 bracket. In addition, death rates were computed for other brackets based on actuarial studies. These withdrawals were then subtracted from the 1960 employment figure, and this amount then subtracted from the 1970 employment projection to give an estimate of the number of new workers needed.

Estimates of the number of jobs to be filled represent an attempt to define shifts in the internal job market during the 1960's. Reflecting the impact of industrial and business machines on the employment of production workers and non-production workers, and on shifts in companies' organizational structures to gain operating economies and to follow the markets, the assumption was made that one out of four jobs vacated by a worker leaving the labor force is not filled. Jobs unfilled resulting from shifts of workers to other occupations were estimated by ratios developed in a study, Manpower and Technological Change in New York State, New York State Department of Labor, 1960.[87]

Withdrawals and net shifts were then subtracted from the total jobs to be filled (or new workers) to derive the number of jobs resulting from industrial growth. This last category reflects additional jobs to be filled because of expected expansion in the area's population and economic base.

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[87] Manpower and Technological Change in New York State, New York State Department of Labor: Albany (1960).

ANALYSES OF DEMAND

BLS Studies

The most notable efforts in analyzing the characteristics of demand and developing statistical relationships of the more important factors affecting future employment are the research by the U. S. Bureau of Labor Statistics; but figuring in parts of their methods are extrapolations, ratios, and the component method.

Noting that there have been revolutionary shifts in the structure of employment in recent decades in the United States, Wolfbein stated that a major factor in determining the manpower requirements in most industries is the level of industrial activity in that sector and that this is related to the overall level of economic activity for the nation.

In projecting occupational demand, it would be desirable to be able to analyze the outlook for production and employment in each of the industries, establishing the nature of the demand for each industry's products or services and the relationship of this industry to the growth of the whole economy. However, because of the resources necessary for this type of study, a more global approach is taken to fill the gaps. The general approach is to project the overall level of economic activity for the nation and to relate this level of activity to employment in each industry, followed by a determination of the occupational requirements in each industry, the supply of workers, and training requirements. In each of its methods, there is a need for judgment in areas such as future changes in productivity, shifts in the relations of demand for products, growth in size and complexity of business organizations, expected growth in research and development activities, and (in some cases) by the supply of workers expected to be available.

Two general approaches have been used to project the overall level of economic activity for the nation. One has been to assume a given level of output during the target period, consistent with an unemployment rate of 3% and an increase of 50% in Gross National Product from 1960 to 1970.

The other approach has been to use the Census Bureau's projections of the size and composition of the population, project the labor force, make an assumption concerning the size of the armed forces, assume full employment or a level of unemployment, and project annual hours of work and output per manhour to arrive at a projection of the overall level of economic activity during the target period. In projecting the labor force, the general approach has been to project labor-force participation rates separately for the various age-sex groups and to apply these rates to the future population in each group. For each of the age-sex groups, trends in labor-force participation rates by age were extrapolated, then weighted by their respective future populations and the resulting labor force summed to provide the total labor force and labor-force participation rate for each age-sex group and for all ages.

In relating estimates of total economic activity to individual industries, the Bureau of Labor Statistics has taken two general approaches. Employment in each industry has been related to total employment in the nation, and production in each industry has been related to total production in the nation. In each of the approaches, before the final projections have been made, judgments have been made concerning future changes in output per manhour, hours of work, demands for products and services, patterns of business investment and government purchases, and competition of other products and services. These judgments were made after observing past relationships of the foregoing, and after discussions with industry and union experts.

Total employment for all industries has been projected and employment in individual industries related to the total. This assumed that the movement of employment in certain individual industries varied characteristically with the fluctuation of total employment. In many industries, the movement of employment has varied in sufficiently characteristic fashion to total employment to make this procedure a useful tool.

Analyzed first were the past relationships between total nonagricultural employment and employment in each of the broad industry divisions. Employment in each of the industry groups within the major industry divisions was then related to the total in the division. Finally, each detailed industry within each of the industry groups was related to the group total. By using this procedure, a consistent set of relationships was obtained. The effect of this method of analyzing the relationship of employment in each industry to total employment was to take into account all of the factors affecting this relationship in the period from which the data used were obtained.

Two methods have been used to relate total production to production in each industry.

BLS has experimented with analyzing the past relationship between the production in each industry and total projected production as a means of projecting industry production levels in much the same way as for employment levels just described, and then translating these industry projections of production into employment by consideration of trends in output per manhour and hours of work. As in the previous method, this was done for the broad industry divisions first and progressively for smaller industry aggregates related to the broad industry division totals. While still essentially mechanistic, this procedure permits a greater number of checks for internal consistency.

The second method of relating total production in the economy to production in each industry is still in the process of development. Total production is allocated among the various industries by the use of interindustry coefficients. This approach is aimed at providing a more comprehensive and integrated framework than previously has been available for analyzing the problems of long-run economic growth in relation to employment opportunities. This method is part of the Economic Growth Studies of the Inter-Agency Committee, which has as one of its primary objectives the development of projections, under alternative assumptions, of the rate and patterns of growth in the economy. This method translates production estimates into employment estimates for individual industries.

Starting with assumptions regarding growth in population, hours worked, and productivity, it projects, under alternative assumptions, total income and output of the economy and the distribution of this output among the various detailed components of final demand for consumption, investment, government expenditures, and foreign trade. The basis for deriving from the output projections comprehensive and consistent estimates of the demand for labor on an industry-by-industry basis will be provided by industry output requirements, projections of hours of work, projections of output per manhour, and expected changes in their trends. In addition to employment data, production information, price indexes, and hours of work by appropriate industry classification are necessary. Data concerning intermediate as well as final demands must be developed in order for the procedure to produce meaningful results. The Office of Business Economics of the Department of Commerce is preparing the interindustry data. The Inter-Agency Growth Committee, housed in the Bureau of Labor Statistics, is in charge of the overall study, and the sections on productivity, employment, earnings, occupations, and related data, are being developed by the BLS.

The results of the various types of analyses are the basis for judgment decisions as to the level of employment in the projected period. Background in making judgments regarding future industry trends may be obtained from data collected and analyzed in the occupational outlook program, discussion with industry and union experts, and from the BLS Technological Outlook studies. In the latter, two approaches to the study of technological outlook are being followed. A series of studies of key industries, analyzing major technological trends and their implications has already produced a report on Technological Trends in 36 Major American Industries, covering the status and outlook of impending developments in each industry. Also being made are a series of studies of different types of innovations that have an impact on a large number of industries.

Data are being compiled on trends in the occupational composition of the various industries and these trends analyzed, but the problems connected with projecting occupational employment are great. The occupational pattern of employment has been changing rapidly, and there is a lack of historical and current statistics. Added to the difficulties is that many factors bring about changes in the occupational composition of employment, and these factors must be analyzed and weighted. Finally, no one technique can be used to project demand in all occupations.

The replacement rate is especially important in projecting the needs for additional persons in some occupations, for example, teachers. Some occupations are so concentrated in one industry (for example, locomotive engineers) that changes in the processes, products, and technology in that industry will reveal the occupational-employment trends in that industry.

There is need for a good current occupational pattern for each industry and a thorough and continuous assessment of technological change and its effect on the occupational structure. In accordance with the Gordon Committee's recommendations, the Bureau of Labor Statistics has begun exploratory work on an employer-oriented collection program to help provide the basic information for these steps. Until data of this magnitude become available, the Bureau of Labor Statistics will continue its attempts to develop projections with whatever data and statistical techniques are available.

As a tool for projecting occupational employment in each industry, the Bureau of Labor Statistics is preparing estimates of the occupational composition of individual industries for future periods. Estimates will be made for about 100 specific occupations in about 125 industries. It plans to apply these future occupational ratios to projections of employment in each industry, and sum the products across all industries to arrive at total employment by occupation for the entire economy.

This occupational-industry matrix for the nation is likely to make a great contribution to the Department of Labor's program of vocational guidance and determining employment opportunities and needs. It will provide information on the number of persons currently employed in specific occupations and on their distribution by industry. Annual estimates of total employment by occupation can be made by applying the most recent occupational composition patterns for each industry in the matrix to estimates of employment by industry.

Occupational projections can be made which will reflect judgments based on trend data on the changing occupational distribution of each industry, analysis of the effects of changing technology, industry product mix, and other information obtained from the occupational outlook studies of major occupations and industries.

As new information on the occupational structure of industries is introduced, studies will be made of the variations in occupational distributions among establishments within industries. An attempt will be made to ascertain the factors which affect the occupational patterns of individual firms within an industry. These factors may be geographic location, product mix, size of plant, and other characteristics of the firm. How rapidly occupational patterns change is also being studied.

The major source of statistical information for the occupational-industry matrix are the data from the decennial censuses of population. The Monthly Report on the Labor Force provides the only complete estimate of employment in the intercensal years. However, there are a number of other sources of good information on one or a few occupations, or on the occupational composition of particular industries. Estimates can be developed from licensure statistics, membership records of professional societies, and Federal agency studies and records. As a result of special studies, Federal agencies have estimates of employment of scientists, engineers, and related technicians; college teachers; librarians; policemen; and elementary and secondary school teachers. In addition, estimates of occupational employment might be developed from the BLS wage-rate studies for about 30 occupations found in many industries plus other occupations which are concentrated in specific industries. Federal government employment by occupation or occupational group can be obtained from the records of the Civil Service Commission. Federal regulatory agencies have records of the occupational structure of the regulated industries (airlines, interstate motor carriers, pipelines, railroads, and telecommunications).

The first step toward making projections of employment by occupation has been to secure the best possible estimates of the occupational composition of about 125 industries for 1960. The U. S. Census of Population Occupation-by-Industry tables have provided the basic data. Then, all estimates of occupational employment that are considered reliable and that may be preferable to Census data have been introduced as constants. In the matrix, this combination of Census and other data was summed horizontally and vertically, but the data were adjusted to fit the pre-determined totals dictated by the occupational-group totals and employment-by-industry totals found in the Monthly Review of the Labor Force.

Industry employment projections will come from the Economic Growth Project, or from other projections of employment by industry.

Occupational patterns for a base period and good projections of employment-by-industry comprise a major step toward projections of employment-by-occupation for a period as short as six to ten years. However, since the occupational composition of industries changes over time, it is necessary to evaluate the changes that are likely to come by 1970 or 1975. When this is carried out as well as possible, the basic work on the future industry-occupational patterns will be completed.

The procedures presently being considered for projecting employment by detailed occupation has certain similarities to the preparation of the matrix for the base period. Estimates from special studies of individual occupations and Federal agency records of employment-by-occupation and occupational patterns for specific industries will be entered into the table for 1970 as constants.

Many of the estimates, however, will be developed by examining trend data on the occupational patterns for each industry and making additional analysis of the effects of technological change, changing product mix, and institutional and other factors on the occupational patterns of the recent past, and how these factors are likely to affect the projection of past trends to the future.

The following trend data are available: (1) The U. S. Census of Population provides detailed occupation-by-industry tables for both 1950 and 1960. The change in the occupation-by-industry pattern from 1950 to 1960 is one of the things the Bureau of Labor Statistics will look at in estimating the occupational pattern for 1970. (2) A second source of trend data is the estimates of employment of production workers and nonproduction workers in detailed manufacturing and mining industries shown in the BLS statistics that have already been compiled from reports to the BLS. (3) The BLS wage-studies data will provide additional indications of the trend for specific occupations in a number of industries through 1963 or 1964. (4) Trend data from licensure statistics, government surveys, and civil service and Federal regulatory agencies' records will also be examined.

Analysis of the effects of technological change will be based on studies of the Office of Productivity or on library research.

Finally, the information for each industry will be adjusted to 100% of the employment-by-industry projections.

The estimates of trend since 1960 for detailed occupations and industries, developed from various sources, will be combined into trends for broad occupational groups in major industries and for the whole economy.

A useful check on projected patterns is to examine the occupational composition of new plants which are utilizing up-to-date methods and equipment, and compare these compositions with the occupational patterns of less modern establishments.

A computer-oriented system will be developed to permit computation of various sets of projected occupational requirements based on different assumptions with respect to the technological and other changes on occupational requirements within groups of industries. This system will make possible a mechanical adjustment to pre-determined totals whenever changes in occupational structure are made, and will provide a means of rapid revision of the industry-occupational matrix to provide current estimates of employment by occupation as new industry employment estimates become available and as new occupational data are developed.

In summary, the procedure proposed for projecting employment by occupation relies on the belief that the occupational patterns for many industries are relatively stable over periods as short as ten years, and that the improved industry-occupational matrix prepared for 1960, combined with a systematic effort to evaluate changes in patterns likely to occur in the near future, will provide occupational ratios for each industry which, when combined with good projections of employment by industry, will yield useful information on employment by occupation for future periods.

After occupational requirements have been determined, the availability of workers to meet these requirements must be estimated. The current supply of workers by occupation must first be determined. Then estimates must be prepared of the additions to and withdrawals from each occupational group over time. These estimates must then be matched against the projected occupational requirements so that areas of potential shortages and dislocations will be evident. Data for the professional occupations and the skilled crafts where institutional requirements must be met (degrees, licenses, and certificates) before the student or trainee is considered fully qualified may be obtained from educational institutions, training facilities, licensing authorities, secondary vocational schools, and organization membership rosters. In addition, persons have become accepted members of their craft or profession through experience or on-the-job training.

The number of people who have to be trained for each occupation must then be estimated by computing the net growth requirements in the occupation and the number of workers needed to replace those dying, retiring, or otherwise leaving the occupation.

Occupational Outlook Handbook[88/]

The Occupational Outlook Handbook, prepared by the Bureau of Labor Statistics, provides current information on nearly 700 kinds of jobs. Their forecasts, some qualitative and some quantitative, are judgmental, based on interviews with persons in industry, unions, etc., data supplied by the research programs of BLS on employment in different industries, productivity, technological developments, etc., on estimates of the numbers of job openings which will be created by retirements and deaths, statistics on high school and college enrollment and graduations, and data on the numbers of apprentices in skilled trades.

A typical statement can be found concerning the outlook for employment as a medical X-ray technician. "Shortages of trained medical X-ray technicians are likely to persist throughout the remainder of the 1960's unless the supply of these workers is increased substantially."[89/] It tells the reader where to go for more information; in the case of those interested in the occupation of medical X-ray technician, to The American Society of X-ray Technicians and The American Registry of Radiologic Technologists.

[88/] Occupational Outlook Handbook, op. cit.

[89/] Ibid., p. 66.

Flanders and Fulton[90]

Flanders and Fulton of the Bureau of Labor Statistics conducted a study on the employment outlook and changing occupational structure in electronics manufacturing. Three steps comprised the study: (1) finding electronic shipment estimates for 1958-1961 and 1970, (2) developing shipments-per-employee estimates and projections, and (3) dividing electronic shipment estimates by shipments-per-employee to get employment totals. In executing the first step, dollar shipments were obtained by major electronic category for the years 1950 to 1962 from the Electronics Industries Association shipment series. For each SIC 4-digit industry which shipped at least $25 million in electronic products in 1958, the estimated per cent which electronics shipments were of total shipments was calculated. This per cent was then applied to total employment in the industry in order to find estimated employment. Involved in this step was the assumption that employment in the manufacture of electronic products may be distinguished with reasonable accuracy from nonelectronic employment by prorating total employment according to proportions of electronics and nonelectronics shipments. The dollar figures were then converted into real dollar figures by deflating the current dollar shipment values for each of the major product categories separately, and real dollar shipments were projected to 1970 by developing projections separately for each major electronic category and adding them together to obtain projections for the entire industry.

The second step was done on the basis of product shipment analyses from the 1958 Census of Manufactures. For each of the twenty 4-digit industries in 1958, the following computations were made. Electronics shipments in each industry were divided by total shipments in that industry and multiplied by total employment in the industry to equal the number of workers in that industry engaged in electronics manufacturing. Electronics shipments were divided by the number of workers in that industry engaged in electronics manufacturing to equal shipments per electronics employee. The figure for shipments per electronics employee was weighted according to the ratio which electronics shipments in that industry bore to electronic shipments in the major electronic product category in which the industry would be classified. These weights gave estimates of shipments-per-employee for 1958 for each of the four major product categories. These estimates were deflated to constant 1960 dollars; and comparable estimates, in 1960 dollars, were developed for 1959, 1960, 1961, and 1970.

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[90] Employment Outlook and Changing Occupational Structure in Electronics Manufacturing, op. cit.

The third step involved dividing the electronic shipment estimates (by product category and year) by shipments-per-employee to get employment totals. This provides the estimates of electronics employment by category and year, but not by occupation.

They obtained their material through talks and interviews with industry, labor, and Federal Government officials engaged in electronics work; periodicals, books, special reports and studies, and newspaper articles; the Electronics Industries Association, a major trade association in this field; Federal legislative committees; Federal agencies; and much unpublished data from the Bureau of Employment Security, e.g., data for their table, "Employment in Electronics Manufacturing, by Region and State, January 1958 and January 1961."[91/]

Their estimates and projections do not cover electronics activity in the Federal Government, universities, and nonprofit research centers.

Michael[92/]

The Bureau of Labor Statistics conducted a study of the long-range demand for scientific and technical personnel for the National Science Foundation. The study was an attempt to develop a method of projecting employment of scientists and engineers, in extensive occupational and industrial detail, for the entire civilian economy; and to develop methods for improving these first approximations through the study of particular sections of the economy.

In appraising future needs for newly trained scientists and engineers, it is necessary to allow for two major components of demand: (1) growth in employment likely to result from economic developments, technological developments, and such other developments as changes in utilization, and (2) replacement requirements brought about by retirements, deaths, and other personal losses (for example, transfers to other fields of work and promotions). There are three possible methods of projecting scientific and technical employment: (1) Ask a sample of

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[91/] Ibid., p. 8.

[92/] The Long-Range Demand for Scientific and Technical Personnel, op. cit.

employers to furnish estimates of their future needs for scientists and engineers. This is used chiefly to assess relatively short-run demand (up to five years). (2) Extrapolate trends indicated by historical data on such employment. (3) Analyze the factors affecting demand for personnel in each occupation and develop projections through statistical relationships of the factors found to have the greatest influence on these requirements. This analytical approach, adapted and simplified, was the method chosen for this study. First approximations of employment and scientific and technical manpower in 1970 was obtained by applying projected ratios of scientific and technical manpower for each sector to projections of total employment. The 1970 ratios, in most cases, were obtained by extrapolating the trends indicated by data covering the 5-year period, 1954-59. The 1970 ratios obtained in the first part of this study reflect an extension of the 1954-59 trends. Therefore, in the 1970 ratios it is assumed that trends in research and development activity, changes in technology, and other factors which specially affect employment of scientists and engineers will follow patterns over the 1960's similar to those prevailing during the latter part of the previous decade.

For private industry employment, data on the employment of scientific and technical personnel came primarily from surveys conducted by the Bureau of Labor Statistics for the National Science Foundation in 1954, 1957, and 1959. When adjustments for problems had been made, ratios of scientific and engineering employment to total employment were computed for 1954, 1957, 1958, and 1959 for each of the industries covered by the surveys. A trend line was fitted to the ratios for each industry and extrapolated to 1970. Then the projected ratios of scientific and engineering employment were multiplied by the Bureau's projections of total employment for 1970, industry by industry. Projections of employment of engineers and of the various scientific professions were derived for each industry by applying an occupational distribution to the projected 1970 employment of total scientists and engineers, the occupational distribution being based on the 1959 distribution but modified where possible on the basis of past trends and other information. Since no trend data were available for technicians, the projections for this occupation were based upon the 1959 ratio of technicians of total scientists and engineers.

Projections of the 1970 colleges and universities employment of scientists and engineers were based largely on projections of total college and university employment prepared by the Office of Education.

Projections were derived separately for Federal, State, and local governments. For Federal government employment, to obtain a first approximation of the future level of scientific and engineering employment, the projected 1970 ratio was multiplied by a 1970 projection of total Federal government employment, prepared by the BLS in connection with its broad study of the country's future manpower requirements. For state government employment, the major source of data on scientific and technical employment was a 1959 BLS-NSF survey. It was decided to make some allowance for the growing utilization of technical personnel by increasing the 1959 ratio of scientists and engineers to State employment by the same percentage as was indicated by the comparable ratios for the Federal government. For local government employment, the first step in deriving projections was to make rough approximations of 1959 employment of engineers and scientists. These estimates were based on preliminary data on scientific and technical personnel in a sample of local government agencies in six states from a pilot study conducted by the BLS for the NSF. The 1959 ratios of scientific to total employment for local governments were increased by the same percentage as was indicated by the comparable ratios for Federal government.

In addition to employment projections for scientists and engineers as a group, separate 1970 employment figures were derived for engineers and for a number of scientific occupations, with the same industry breakdown as in the overall figures. For a few industries initial projections of 1970 employment of technicians were also prepared by similar methods.

In general, it is believed that the projections for the largest occupations such as engineers and chemists are reasonable; but that much more detailed study of the smaller occupations, such as physicists and mathematicians, would be needed to produce reliable projections, because they are subject to such marked changes resulting from new developments in science and technology.

It might be suggested that the increase in the employment of scientific and technical personnel between 1954 and 1959 was due in part to more ample supply. If this were so, the upward trend in employment ratios may somewhat overstate the actual rise in demand and this would give the projections some upward bias.

A more comprehensive investigation of the validity of the extrapolated ratios was made for the chemicals and electrical equipment industries. The chief purpose of the special industry studies was to determine whether studies of this kind would provide a basis for assessing and, if necessary, modifying, projections of scientific and engineering employment. For these two industries, detailed analysis was attempted from all available data which may have influenced trends in employment of scientific and engineering personnel and the ratio of scientific and engineering manpower to total employment. To accomplish this analysis, a sample of employers in each industry was interviewed. They were shown charts and tables depicting the past growth of scientific and engineering employment and the 1970 projections of such employment for the industry which had been derived on a preliminary basis. They were asked their opinions of the projections and how reliable their own companies' past forecasts had proven to be. All of the estimates for the interviewed companies in each industry, given or derived, were combined to yield overall estimates of the 1970 employment of scientists and engineers and all employees for the chemicals or electrical industry, respectively.

The results of the detailed study in the chemicals industry tended to confirm the first approximations. For the electrical equipment industry, however, some modification of the projections was indicated.

The chemicals industry is among the largest industrial employers of technicians with about 34,000 on its payrolls in 1959. More than 45% of these were in research and development. The rate of gain in employment of scientific and technical personnel from 1954 to 1959 significantly exceeded the rate of increase in the industry's work force, which rose by 1.7% a year during this period. Many of the scientific and technical personnel are directly concerned with the industry's advancing technology and expanded research program. The proportion which scientists and engineers represented of the industry's total work force rose at an average annual rate of 4%. For the period 1954-1959, the trends in the ratios of scientists and engineers to total employment were of fundamental importance in this project because of their use in developing projections of future employment. Statistics on nonproduction workers (broadly speaking, all white-collar workers) compiled by the BLS were also relevant to this analysis. These include professional, administrative, technical, clerical, and sales workers.

One main aspect of this detailed analysis concerned the anticipated increase in total employment in this industry. Rapid technological advances, as in the past, will permit the industry to increase its output significantly with only a relatively small increase, probably 33%, in total employment between 1959 and 1970.

Employment of technicians was projected at the same rate of increase as that of scientists and engineers (82%), showing a rise from about 34,000 in 1959 to 63,000 in 1970.

When aggregated, projections developed from discussions with individual company officials of the interview sample in the chemicals industry and those supplied by company officials showed a 63% increase in scientific and engineering employment for these companies between 1959 and 1970 compared with an 82% increase which had been projected for the chemical industries as a whole. The difference between rate of increase between the industry and the interview companies apparently is explained by the large size of most of the interview companies, since the small firms are the ones which have been achieving the most rapid rates of growth in scientific and engineering staffs. In all probability, they will continue their rapid growth.

The officials of chemicals companies interviewed were generally of the opinion that the ratios of technicians to scientists and engineers would increase over the next ten years both in their companies and in the industry as a whole.

The electrical equipment industry is second only to the transportation equipment industry in the number of scientists and engineers employed and leads even this industry in employment of technicians. This is because of the highly technical nature of most electronic and electrical products and the large amount of research performed. Detailed information on employment of scientists and engineers in the electrical equipment industry is available only for the 1954-59 period covered by the BLS-NSF surveys. The proportion that chemists and engineers represented of total employment in the industry increased from 4.6% in 1940 to 4.9% in 1950, an average annual rate of less than 1%. The proportion increased at an average rate of more than 6% per year, however, between 1954 and 1959, roughly the same as the increase in the ratio of total scientists and engineers to total employment shown in the BLS-NSF surveys.

Statistics on nonproduction workers also help in analyzing the 1954-59 period, since engineers and scientists represent about 24% of nonproduction worker employment in the electrical equipment industry. When technicians are added, the proportion is increased to about 41%.

In discussions with company officials regarding trends in past and expected employment, doubts were raised as to whether the 1954-59 period is a completely satisfactory one to use as a basis for projections for this industry. The interview companies in the electrical equipment industry as a group indicated that the initial projections of scientific and engineering employment were somewhat too high. However, these companies were expecting a substantial increase in their employment of scientists and engineers. In the years through 1959, the interview companies in the electrical equipment industry, like those in the chemicals industry, increased their employment of scientists and engineers at not quite three-fourths (73%) of the rate for the electrical equipment industry as a whole. Statements from company officials interviewed indicated that as a group their companies expected little or no increase in 1970 in their employment of technicians relative to that of scientists and engineers.

The levels of scientific and engineering employment in 1970 implied for the country as a whole can be anticipated in large measure by aggregating the projections for the different sectors of the economy. To complete the picture of scientific and engineering employment for the entire civilian economy, it is necessary, however, to make allowance also for a few areas of employment which were not covered by the basic data for private industry, colleges and universities, and government.

To arrive at an assessment of the nation's future education and training needs, it is necessary to develop estimates of demand and know a great deal about the sources of supply of scientific and engineering manpower.

To derive estimates of losses owing to retirements and deaths, appropriate separation rates developed from Tables of Working Life: Length of Working Life for Men[93/] (BLS, Bul. 1001, 1950) were applied to the numbers of engineers, chemists, and other natural scientists in different age groups, as reported in the 1950 Census of Population. One of the major problems in making estimates of the number of engineering graduates who will be needed is the fact that, in addition to college graduates with degrees in engineering, significant numbers of persons will enter the profession without college degrees or with degrees in fields other than engineering. To compound the difficulty, one year after graduation, about 14% of the engineering graduates were employed in other fields, according to a sample study of the education and employment specialization of 1951 college graduates.

Projections prepared by the Office of Education indicate that degrees awarded in all fields will increase more than 80% between 1959 and 1969, assuming that the necessary educational facilities and faculty are available and demand is sustained. There is evidence from many sources indicating that a very large percentage of persons receiving bachelor's and master's degrees in science do not enter civilian

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[93/] Tables of Working Life for Men, U. S. Department of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office (1950).

employment in their fields of scholastic specialization. According to the National Science Foundation follow-up study of 1951 college graduates,[94] three-fourths of the new graduates with bachelor's degrees and three-fifths of those with master's degrees in science did not obtain work in one of the sciences in the year in which they received their degrees. The analysis excluded new graduates entering the Armed Forces and those receiving bachelor's degrees and entering graduate school in science were considered as new entrants in the field of science. The exact figure used to represent the proportion of all science graduates entering scientific work has a very great effect on the possible conclusion. Thus, if the proportion of new graduates with degrees in science who do not enter scientific employment should be 80%, rather than the 70% used in the analysis, then the supply of new science graduates per year would have to increase considerably to meet the projected requirements.

By way of evaluating the analysis, one of the chief advantages of these comprehensive projections is that they were built up by aggregating separately derived projections for all major segments of the civilian economy. The special studies of the chemical and electrical equipment industries illustrate that improvements upon the overall projections are possible through a more detailed analysis of particular industries. Altogether, the information obtained from employers, which was supplemented by other evidence, appeared to represent a reasonable basis for assessing and modifying the initial projections of future scientific and technical employment in the two industries. The statistics on scientific and engineering employment in colleges and universities, State governments, and, above all, local governments, were either inadequate, or available only in rough preliminary form when this study was conducted.

The projections of total employment by industry for 1970 were prepared by BLS as part of a comprehensive study of the country's manpower needs and resources in _Manpower Needs and Resources of the United States 1960-1975, Part I, Summary of Findings and Implications_ (unpublished report of the Bureau of Labor Statistics). The population projections which were used were the Series III projections published in _Current Population Reports, Series P-25_, No. 187, U. S. Department of Commerce, Bureau of the Census. Projections for the labor force were made by

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[94] National Science Foundation, _Education and Employment Specialization in 1952 of June 1951 College Graduates_, Washington: U. S. Government Printing Office (1954).

multiplying the population projections for each age and sex group by an estimated labor force participation rate for that group, projected by a study of past trends in labor force participation rates and consideration of such factors as school attendance, presence of young children in the home, and recent patterns of retirement. A thorough discussion of the techniques and analysis used in estimating labor force participation rates and the growth of the labor force is included in BLS Bulletin 1242 (1959) Population and Labor Force Projections for the United States, 1960 to 1975. GNP projections were based on projections of gross product for each of three broad segments of the economy -- agriculture, government, and the private sector outside of agriculture. In making estimates of employment in individual industries, a first approximation was made, based on past relationships of that industry's activity to the total level of economic activity. Then analysis was done by means of regression techniques. The first approximation which was obtained from this procedure was examined in the light of additional employment projections for many individual industries, made separately by analyzing the factors affecting employment in the industry.

Sugg[95]

It is feasible to project manpower requirements by extrapolating past trends in a highly developed industrial economy undergoing no radical change in the structure of society or political orientation.[96] However, in a developing economy, in many cases, data from other countries can be more useful than data for the subject country. For example, this would be true in developing occupational requirements for projected industry levels where the industry does not yet exist in its projected form. Also, where the existing industry in the developing nation is small, its occupational structure may be quite different from the industry at its projected level.

Sugg of the Bureau of Labor Statistics developed a handbook on the forecasting of manpower requirements with emphasis on under-developed areas, but the same technique could be applied to any area for which data is skimpy. The method involves five steps. (1) Derive a rough first approximation of the future employment structure by economic activity. (2) Make a detailed analysis of each important economic activity, arriving at an estimate of future employment. (3) Modify the first approximations of future employment in accordance with the results of the detailed analysis of each important activity. (4) Derive an occupational breakdown of employment of each economic activity in the future period. Sum the estimates of each occupation from the various economic activities. (5) Estimate training requirements for each important occupation. These steps are described in more detail below.

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[95] The Forecasting of Manpower Requirements, op. cit.

[96] Wolfbein, op. cit., p. 28.

(1) Derive a rough first approximation of the future employment structure by economic activity. This approximation will be consistent with the anticipated increase in the labor force. Unemployment will probably be assumed at 4% of the labor force. If no historical data is available, make an assumption of proportionality. This is the assumption that employment in every division will have the same percentage increase as total employment. At this stage, no detailed study of each component of the industry is made. If data for ten or more years are available, it is possible to estimate the future employment in each industry division by correlation analysis (that is, by reference to past correlations between nonagricultural employment and employment in each division, and by projecting this relationship into the future). It may actually be known that certain dynamic changes are likely to affect future employment in specific activities in a manner significantly different from past experience. Therefore, the analyst may find it necessary to modify the estimates on a judgment basis.

(2) Make a detailed analysis of each important economic activity, arriving at an estimate of future employment. Take into account anticipated changes in the demand for its products or services, hours worked, and productivity. As a contrast to the "traditional sector" of peasant agriculture, handicrafts and small-scale industry, and the financial transport, distribution and other services associated with these activities, the modern sector is characterized by high capital-labor ratios, capital accumulation, technological progress, relatively high productivity per man-hour, and provision of wage-earning employment. Information about construction plans may be obtained from planning agencies of the government, offices which issue building permits, employer associations, and finance agencies. Certain industries can be studied in relation to population growth (food and beverages, clothing and footwear, shelter, education and medical care, and electricity, gas, water, and sanitary services). Information and insight into problems can be obtained through personal interviews with people in

industry, government, trade associations, and labor unions. Four types of information for each activity to be analyzed should be assembled: (a) a description of the economic activity, as currently constituted; (b) a descriptive and statistical historical background, showing trends in employment, hours, earnings, production, output per worker, technological progress, occupations, and exports; (c) the nature of the demand for the product or service; and (d) factors which may affect the future growth or decline of the industry. Published data may be found in the censuses; labor statistics bulletins; statistical publications on national income, foreign trade, and financial statistics; trade journals, directories, and publications; financial and other reports of industries; daily newspapers; news magazines; and publications of trade associations, labor unions, chambers of commerce, and professional societies. The analytical document prepared for each economic activity to be analyzed should have two parts: (a) arriving at judgments on the level of productivity (output per man-hour) at the forecast data, and the hours of work at the forecast data; and (b) utilizing these judgments to derive the estimated employment level at the forecast data. In estimating the change in productivity during the forecast period, the question is, how much will employment increase in order to produce the new production level? Productivity is defined as $\frac{\text{Production}}{\text{Man-hours}}$ = Output per man-hour. Therefore, $\frac{\text{Production}}{\text{Output per man-hour}}$ = Man-hours and $\frac{\text{Total man-hours}}{\text{Man-hours per worker}}$ = Number of workers. Conceptually, in utilizing this basic structure, computation of the estimate of future employment can be made in a clear-cut manner; but, in practice, this procedure is complicated, difficult, and hazardous because of the uncertainties involved.

(3) The first approximations of future employment will be modified in accordance with the results of the detailed analysis of each important activity. This is done by fitting the conclusions of the analysis of important industries into the whole, and verifying the results by an analysis of gross domestic product. "When gross domestic product per person employed is known for each economic activity for the base year, an estimate of that product for the future year may be derived, consistent with the assumptions which have been incorporated into the preceding projections."[97]

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[97] *The Forecasting of Manpower Requirements*, *op. cit.*, p. 45.

(4) An occupational breakdown of employment in each economic activity in the future period will be derived. This will be done applying the best available occupational composition patterns to the previously derived estimates of employment in each industry or each economic activity. Then the estimates of each occupation from the various economic activities will be summed. Particular attention should be given to all occupations requiring specialized training or education. One analytical technique is to study the occupational composition of plants which have the most up-to-date technology. This is done because, over a period of years, other plants in the industry probably will introduce the new equipment or production methods. There are a few occupations for which the demand is directly related to a factor which can be projected independently.

(5) Estimate training requirements for each important activity. This is done by an analysis of the expected supply of qualified workers, in comparison with the requirements as indicated by the occupational estimates for the future period. There are five steps in the analysis. (a) Determine the current number of qualified workers in each occupational category. This consists of those who are currently employed in the occupation plus those persons who are qualified for, and capable of working in, the occupation, but who are not so engaged. (b) Deduct outflows, due to deaths, retirements, transfers to other occupations, and emigration. The death and retirement rates shown by Wolfbein in Tables of Working Life for Men, Tables of Working Life for Women,[98] and Length of Working Life,[99] can be used. (c) Add inflows. Estimate the number of entrants to the occupation from sources such as college courses, vocational courses, apprenticeship programs, on-the-job training and upgrading of skills, transfers from other occupations, and immigration.

Harms[100]

Harms is developing a model for projecting industry and occupational employment in five areas (two standard metropolitan statistical areas and three counties) which differ as to resources, industries, and markets, to 1965, 1970, 1975, and 1980. His procedure involves analyzing historical data for trends, projecting the basic trends, and then engaging in a further analysis in order to gain an understanding of the forces which produced the trends and thereby obtaining a judgment about the likelihood of the persistence of those trends. These judgments can then be given weights which would produce modifications of the trends if projected into the future. The analysis of the data has for its basis the economic theories relevant to the data, primarily, in this case, employment theory.

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[98] Op. cit.

[99] Seymour L. Wolfbein, Length of Working Life, (Paper presented before the Fourth International Gerontological Congress, Merano, Italy, July 1957).

[100] To Develop a Model or Models for Projecting Employment by Industry and by Occupation for Counties, Labor Market Areas, or SMSA's Together With Appropriate Data, op. cit.

His method involves 14 steps. (1) Show employment by industry and occupation, annually from 1950 to 1963, for 12 industry categories. The 12 industry categories are the following:[101]

Category 1 -- Primary resource extractors producing for the nonfinal market, including

Agriculture
Forestry and fisheries
Mining
Logging

Category 2 -- First stage resource users producing for the nonfinal market, including

Sawmills, planing mills, and millwork
Structural clay products
Miscellaneous nonmetallic mineral and stone products
Grain mill products
Dyeing and finishing textiles, except knit goods
Petroleum refining

Category 3 -- First stage resource users producing for the final market, including

Meat products
Dairy products
Canning and preserving fruits, vegetables, and seafoods
Confectionery and related products
Beverage industries
Miscellaneous food preparations and kindred products
Not specified food industries
Tobacco manufactures

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[101] Adapted by Harms from Duncan, Otis and Associates, Metropolis and Region, Baltimore: The Johns Hopkins Press (1961), pp. 200-209.

Category 4 -- Second stage resource user, producing for the nonfinal market, including

Miscellaneous wood products
Blast furnaces, steel works, and rolling mills
Other primary iron and steel industries
Cement, and concrete, gypsum, and plaster products
Yarn, thread, and fabric mills
Miscellaneous textile mill products
Synthetic fibers
Paints, varnishes, and related products
Miscellaneous chemicals and allied products
Pulp, paper, and paperboard mills
Miscellaneous petroleum and coal products

Category 5 -- Second stage resource users producing for the final market, including

Furniture and fixtures
Bakery products
Knitting mills
Carpets, rugs, and other floor coverings
Apparel and other fabricated textile products

Category 6 -- Resources of indirect significance producing for the nonfinal market, including

Primary nonferrous industries
Fabricated metal industries (incl. not specified metal)
Machinery, except electrical
Electrical machinery, equipment, and supplies
Motor vehicles and motor vehicle equipment
Ship and boat building and repairing
Railroad and miscellaneous transportation equipment
Glass and glass products
Pottery and related products
Professional equipment and supplies
Photographic equipment and supplies
Printing, publishing, and allied industries
Drugs and medicines
Paperboard containers and boxes
Miscellaneous paper and pulp products
Rubber products
Leather: tanned, curried, and finished
Not specified manufacturing industries

Category 7 -- Resources of indirect significance producing for the final market, including

Aircraft and parts
Watches, clocks, and clockwork operated devices
Miscellaneous manufacturing industries
Footwear, except rubber
Leather products, except footwear

Category 8 -- Local service industries, including

- Street railways and bus lines
- Taxicab service
- Telephone (wire and radio)
- Electric light and power, and electric-gas utilities
- Gas and steam supply systems
- Water supply
- Sanitary services
- Retail trade
- Real estate (including real estate-insurance-law offices)
- Accounting, auditing and bookkeeping services
- Miscellaneous business services
- Repair services
- Private households
- Other personal services
- Theaters and motion pictures
- Bowling alleys, billiard and pool parlors
- Medical and other health services, except hospitals
- Welfare and religious services
- Nonprofit membership organizations
- Legal services
- Engineering and architectural services
- Postal service
- Local public administration

Category 9 -- Nonlocal service industries, including

- Railroads and railway express service
- Trucking service and warehousing
- Water transportation
- Air transportation
- Petroleum and gasoline pipe lines
- Services incidental to transportation
- Telegraph (wire and radio)
- Other and not specified utilities
- Wholesale trade
- Banking and credit agencies
- Security and commodity brokerage, and investment companies
- Advertising
- Hotels and lodging places
- Radio broadcasting and television
- Miscellaneous professional and related services
- Federal public administration
- State public administration

Category 10 -- Service industries which may be local or nonlocal, including

- Insurance
- Miscellaneous entertainment and recreation services
- Hospitals
- Educational services, government
- Educational services, private

Category 11 -- Construction

Construction

Category 12 -- Industry not reported

Industry not reported

Census of population data for 1950 and 1960 will be used. Annual data for industries from the Bureau of Employment Security and other sources will be interpolated between census dates and extrapolated to 1963. Annual data for occupations will be interpolated on the basis of annual total county employment and national survey occupation data. The data will be adjusted (a) for classification changes between the two census years, (b) to fit the 1957 standard industrial classification, (c) to be all for March of each year, and (d) for underenumeration of each year. (2) Identify key industries. This is done by calculating the locational quotients of each of the 12 industry categories, and will show whether industry employment is tied to a local resource or local demand or state, regional, or national markets. The key local industries are determined by computing percentage distributions. See Table 3. (3) Compute the weights of local, state, regional, and national factors in local area employment at various dates, in order to note changes in the relative importance of industries. (4) Identify key employment categories according to relative importance locally, regionally, and nationally, from Table 3. (5) Examine the factors of the key-industry categories which are associated with their relative importance. For the resource-oriented industries, the factors will be dependence on local or nonlocal resources, factors affecting availability of resources (cost, quantity, quality, technology), and demand for resources (whether population-determined or income-determined competing products). For the secondary (processing and manufacturing) industries, the factors will be demand (whether local or non-local, population-determined or income-determined, competing products) and cost factors (cost, quantity available, and quality of materials and changing technology). For the service industries, the factors will be demand (population-oriented or industry-oriented) and supply of labor and other skills. (6) Project mechanically key-industry employment trends, based on the assumption that the forces at work producing the trends will continue to produce the trends in the future. (7) Identify relationships from Step 5 and develop projective combinations. If an industry's demand comes from the national market, the proportion may be projected if there is a national projection, which is likely. An output index may be used. For some industries, per capita income or population are the appropriate measures. If a service industry is consistently related to a

TABLE 3

BASIS FOR SELECTING KEY INDUSTRIES PERCENTAGE DISTRIBUTIONS AND LOCATIONAL QUOTIENTS

____
(Area)

____
(Date)

Industry Category*#	Percent of Employed Labor Force		Locational Quotient	Difference Between U. S. and Area	
	U. S. (1)	Area (2)	Col. (2) ÷ Col. (1) (3)	Col. (1) - Col. (2) (4) +	(5) -
1	7.7				
2	-				
3	2.8				
4	4.7				
5	3.5				
6	16.1				
7	-				
8	20.8				
9	22.5				
10	12.0				
11	5.9				
12	4.8				

Columns (1), (2) U. S. Census of Population: 1960, 1950 and annual estimates, 1950 - 1963

*Based on table in Appendix.

#Each industry of employment can next be identified as to whether its

a. inputs come from
b. outputs go to
}
1. the area itself
2. the surrounding region
3. the state or nation

Source: Research Proposal by Louis T. Harms to the Office of Manpower, Automation, and Training.

national industry, this relationship may be projected, or an output index may be used. If an industry is increasing its output per man-hour, the projected employment trend will be weighted by anticipated changes in a productivity index. If the resource or other industry upon which the area's economy was based has given out, a desired level of employment may be projected, weighted by some other substituted distribution than the projected trend. The substituted distribution would be the one planned for by the community. (8) Identify factors tending to maintain or change relationships projected in Step 7, which will change the weights given to the projections. Set up a table, showing for each year, the changing weights in the long-term projection of an industry's employment. A projected employment trend can be modified by a projected labor-saving trend. The labor-saving weights can be offset by a projected shortening of hours and by increases in the demand for the output of the firm. Set up a paradigm which is intended to show how projected trends might be modified by increasing productivity, shortening hours and changes in demand. (9) As current data become available, the projections will be modified because of changing weights, such as market demand changes, productivity changes, political changes, and program changes. (10) Make short-term projections by a detailed analysis of an area's employment based on the table of locational quotients. A comparison of an area's industry employment with that of the state and nation can show the degree to which the industry is dependent upon local or wider markets for its employment. For example, an analysis was made of an hypothetical Labor Market Area employment in the apparel industry which showed a specialization ratio of 0.317, indicating dependence on outside markets for that portion of the employment and on local markets of 0.683 of its annual employment. These constants were then applied to monthly employment data for a three-year period and a multiplier of 1.97 computed. If the non-local employment were projected, the local portion could be estimated with this multiplier and the total employment projected on this basis for the shorter period. (11) Isolate trends of employment by occupation. This will be done on the basis of annual estimates, which in turn are based on decennial census occupational data, 1950 and 1960 and the national monthly surveys, together with the industry by occupation matrices where available for standard metropolitan statistical areas. For non-SMSA data, refined state matrices may be developed as the bases for determining the trends of employment of occupations. (12) Project trends of employment by occupation for areas in the detail available, on the assumption that historical factors will continue to produce revealed trends. (13) Compute the percentage of each occupation in each industry. The trend of these percentages will then be used as weights to compute the projected occupations in each industry for 1965, 1970, 1975, and 1980. (14) If the analysis of the factors affecting the employment by industry shows that future trends in occupational employment are likely to change, the projections will be weighted accordingly.

The study is an involved one. For example, in order to accomplish the first two steps, the following 27 tasks must be performed:

1. U. S. employment by industry -- 1950 Census.
2. Multiply each by 103% for 1950 underenumeration.
3. U. S. employment by industry -- 1960 census.
4. Census classification changes, 1950-1960.
5. SIC classification changes -- 1957.
6. Put the figures in the Otis categories.
7. Adjust SIC BES classification to Census.
8. Trend ratio for each industry, 1950-1960.
9. BES employment by industry each April, 1950-1964.
10. Put the figures in the Otis categories, after SIC adjustment and adjustment to Census classifications.
11. Adjust to Census levels for 1950 and 1960 and trend ratio.
12. Run percentages of each Otis category of total employment.
13. SMA employment by industry -- 1950 Census.
14. Adjust Colorado Department of Employment (CDE) figures (1951) (SIC) to Census classification (1950).
15. Fabricate figures for Boulder County 1950 by breaking out detailed industries by CDE portions of industry groups in Boulder County for 1951 and applying these to Census groupings for Boulder County 1950
16. Add Boulder County (fabricated) to SMA (Census) for Census 1950 SMSA.
17. SMSA employment by industry -- 1960 Census.
18. Classification changes Census, 1950-1960.
19. Put in Otis categories.
20. Trend ratio from 1950 to 1960.
21. CDE employment by industry each April, 1950-1964.
22. Adjust for SIC changes -- 1957.
23. Adjust to Census classifications.
24. Put in Otis categories.
25. Adjust to Census 1950 and 1960 and trend ratio.
26. Run percentages of each Otis category of total employment.
27. U. S. Otis categories divided by SMSA Otis categories each year.

Arrington[102]

By examining statistical data in the decennial census reports, Arrington answers fundamental questions relating to the economic life of the American West and the relation of that region to the East. He makes no attempt to project, but supplies an historical insight into economic relationships as a basis for making judgments concerning the future when statistical techniques for projection are not yet well enough developed to make accurate projections.

In his monograph, Arrington reveals the export-import relations of the various states in the Mountain West with each other and with the East. A tentative attempt to apply this method to one state had already been made.

In The Changing Structure of the Mountain West,[103] Arrington presents statistical tables on (1) the industrial structure of the Mountain West (number and per cent of those occupied), (2) the leading export occupations and industries in the Mountain States from 1850 to 1950, and (3) the per cent employed in export industries in the Mountain States from 1850 to 1950. The concept of a basic industry is best set forth in the collection of articles by Richard B. Andrews in Land Economics, XXIX-XXXII (1953-1956); and in Ralph W. Pfouts, ed., The Techniques of Urban Economic Analysis (1960).[104] Basic industries must provide a means of support not derived from other industries in the area and, thereby, are industries which produce for export. North maintains that the determinants of the timing and pace of an economy's development are "(1) the success of its export sector, and (2) the characteristics of the export industry and the disposition of the income received from the export sector."[105] Arrington contends that this goes too far; for where areas have drawn settlers for reasons other than the profit motive, there may develop a self-sufficing agricultural society where agriculture, as the basic industry, does not produce for export. He points to the recent growth of Arizona, New Mexico, Florida and California as stemming from climate-seeking new residents.

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[102] Op. cit.

[103] Ibid., p. 9.

[104] Ibid.

[105] Douglass North, The Economic Growth of the United States, 1790-1860, Englewood Cliffs, N. J.: Prentice-Hall (1961), p. 1, as quoted in Arrington, op. cit., p. 11.

However, export-base industries usually cause investment and inducement of economic growth. The export-intensity of an industry can be measured by calculating a location-quotient. This is done by dividing the per cent engaged in a certain industry in a given area by the per cent engaged in that industry in the nation as a whole. A location-quotient of 1.0 or over tends to indicate an export industry, whereas less than 1.0 probably produces on an import basis or is a service industry. The principal export-base industries of the Mountain West have been mining, stockraising, transportation, and Federal enterprises, including military.

Assuming that the size of the export quotient is a measure of the degree to which a given industry is on an export basis, the per cent of persons employed in the export industry can be calculated by reversing the export quotient. The relationship of the total export employment to the total number of employed persons in the area shows the per cent employed for export in each area for the year.

Arrington noted three historical patterns of Western economic life -- the pastoral Spanish ranchos, the self-sufficing Mormons, and the later highly-specialized, exploitative economies of Colorado, Nevada, Idaho, Montana, Arizona, and Wyoming. As a consequence, Colorado and five other states made the most noticeable contribution to the emerging capitalism of the nation, featuring the colonialistic economy.[106/]

Four qualitative changes have occurred in the Mountain West since 1940. The climate and beauty of the region have made tourism a major industry. Mining and agriculture have become less important than previously. Manufacturing has increased tremendously and is now significant in the Mountain West for the first time, although it is still proportionately far less important for the Mountain West than for the United States as a whole. The Mountain West has traditionally received a larger portion of defense outlays of the Federal government than its population proportion.

Arrington anticipates that these trends will continue, with expansion of tourism, manufacturing, and the military industries, and further contraction of mining and agriculture.

The historical method projects the present trends, unless there is some good reason to believe that the trends will not continue. This would anticipate projecting the long historical trend of total employment and employment by sector.

[106/] Arrington, _op_. _cit_., pp. 19-21.

Halaas, Plank, Zubrow[107]

Halaas, Plank, Zubrow, and others, in 1958, constituted a tax study group which prepared a report on financing government in Colorado for the Governor of Colorado. Part of this report consisted of a description of the economy of Colorado and recent developments and future outlook of its principal industries. The study indicated some of the causal forces of expansion and contraction in the various industry categories.

The report considered the migration, density, geographical distribution, age pattern, and educational level of the population; total personal income, per capita income, per capita income by counties, and stability of total income; employment trends; industrial specialization and basic industries; recent developments and future outlook of the principal industries; industrial progress and the question of water; and reviewed some population, employment and income projections.

In regard to employment trends, a study was made of population and employment relationships, population and employment growth in Colorado compared with the United States, sources of new employment 1940-1950, sources of new employment 1950-1956, and the industrial pattern of employment.

A detailed view was given of the particular industries in which Colorado has tended to specialize and presumably is most capable of attracting, as well as those which are relatively underdeveloped in the state. An index of local specialization was calculated, indicating the importance of an industry to the nation. The index was derived by dividing the ratio of a local industry's employment to the total employment in the locality by the comparable ratio for the industry as a whole on a nation-wide basis.

Basic employment was calculated by determining the number of workers in a local industry in excess of the area's pro rata share of national employment in that industry. An excess of workers is presumed to measure its "export" significance and its relative importance as a "basic industry." In utilizing this method of determining an industry's export quotient, the authors caution,

> It should be noted that a greater than pro rata share of industry employment could, in part at least, be attributed to an unusually heavy local per capita consumption of a particular industrial product. Moreover, low productivity of local labor could also be a contributing factor. Accordingly,

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[107] Financing Government in Colorado, op. cit.

some discretion is called for in the interpretation and application of basic employment analysis in any given case.[108]

The industries analyzed included agriculture, mining (including petroleum, oil shale, uranium, molybdenum, and coal), manufacturing, wholesale trade, retail trade, selected services, tourist trade, and government.

The report discusses two studies of future population trends in Colorado, the Bureau of the Census projections of Colorado's population by five-year intervals from 1955 to 1970 and Peterson's projections of the population of Colorado, the western slope, the eastern slope, and the Denver Metropolitan Area to 1970.[109] The Study Group estimated Colorado's total employment in 1970. Welles estimated per capita personal income in Colorado in 1970.

Denver Research Institute[110]

In 1963, the Denver Research Institute of the University of Denver completed an economic analysis of the forces influencing the development of Colorado, and a 1970 forecast of economic activity in Colorado. The report contained an economic history of Colorado; an analysis of the industries of Colorado; 1970 projections of Colorado employment by industry, population, and income; and its methodology of analysis and projections contained an evaluation of employment data and a construction of a historical employment series from 1870 to 1940 and a derivation of current employment series from 1950 to 1962. The economic history of Colorado focused attention on the nature of the economy today and on the why and how of its development. The primary purpose of the study of the economic history of Colorado was to provide an understanding of Colorado's present economy by identifying and describing the long-run economic forces which have influenced the state. The analysis dealt with three major economic factors -- population, employment, and income. It divided Colorado's history into three eras: mining (1880-1900), agriculture (1900-1940), and defense (1940-1960). It began the analysis by defining "per capita personal income," "labor participation rate," "labor participation rate adjustment," "actual per capita earning power," "industry contribution to actual earning power," and "basic income."

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[108] _Ibid_., p. 48.

[109] _Ibid_., p. 62.

[110] Mahar, Coddington, and Gilmore, _op_. _cit_.

In the section on the era of mining, attention was focused on the direct economic effects of this industry. It also provided some dramatic examples of the importance of institutional and political actions on the economic development of the state. The report described the types of mining in Colorado; technological innovations in mining; the impact of mining on transportation, services, agriculture, and the food processing industries; the significance of manufacturing; population; per capita income comparisons between Colorado and the United States; a comparison of the industrial sources of income as between Colorado and the United States; and the possibility of the development of an oil shale industry in Colorado.

In the section on the era of agriculture, the report analyzed the dominant role of agriculture, the decrease in the importance of mining, the orientation of manufacturing toward food processing, the "other" industries, and the continued increase of population.

In the era of defense section, the report described the economic effects of World War II on the Colorado economy, the post-World War II period, the restimulation of the Korean War with its special effects on the mining industry, the effects of the Cold War, and the indirect effects of defense spending. The continuation of the resource-orientation of manufacturing, the increased output but stable employment of mining, the years of prosperity but declining employment in agriculture, the increase in importance of all other industries, and the substantial increase in per capita income were described.

The second part of the report developed 1970 forecasts of employment in the different economic sectors, and 1970 estimates of population and income which stem from the employment forecasts. The detailed study of economic growth relied mainly on employment data, in the belief that examination of the causes of changes in employment, industry-by-industry, provides the most helpful clues as to the causes of economic changes. Furthermore, employment data are available on more comprehensive and consistent bases than output data, which were assembled only for selected industries. By building up industry-by-industry forecasts of employment, total employment estimates were derived which, in turn, provided the bases for population and income projections.

In the industry-by-industry analysis, the major emphasis was placed on the five major basic Colorado industries -- agriculture, mining, manufacturing, government, and tourism. The historical development of mining and agriculture was treated in considerable detail in the first part of the report. In the description of the era of defense, the manufacturing industry and Federal government expenditures were extensively described. While the available data on tourism is incomplete, efforts were made in the analysis to relate tourism to the trade and services sectors.

The analysis did not include major discontinuities, such as developments of the magnitude of the location of the Martin Company Titan Missile facility in the Denver area, since they are almost entirely unpredictable and therefore outside the realm of a formal forecast. The forecast of employment assumed that there would be minor recessions but no major depression between 1962 and 1970, and no major war, but continued defense and space expenditures at slightly increasing levels. The basic forecast assumed 1970 Gross National Product of $787.7 billion in 1960 prices. This figure was taken from the "Judgment Model" constructed by the National Planning Association.

Where data were available, efforts first were made to predict the output in dollar terms of an individual industry, and then to predict the output per man-hour in this same industry. By dividing forecasts of output by forecasts of output per man-hour, it was then possible to estimate future employment.

However, in most cases, it was necessary to make direct employment estimates based on analysis and knowledge of industry trends in output and output per worker. Direct employment estimates were made in mining, manufacturing, transportation, communications and utilities, and in government.

In those industries (finance, insurance and real estate, services, wholesale and retail trade, and construction) which are largely dependent on the basic industries, the basic elements of each (10% of total in most cases) were identified, and employment in this portion of each industry was estimated using the direct method just described. A ratio approach was used for the remainder of each industry, which compares the ratio of past employment of each industry to total Colorado employment, and then projections of this ratio to 1970 were made. Trends for the United States were also considered in estimating the proportion of employment in each industry.

Throughout the forecasting process, opinions and viewpoints of qualified consultants and observers in specific industries were obtained. This information was particularly helpful in agriculture, mining, selected manufacturing industries, construction, transportation, communication, public utilities, and tourism. A range of employment estimates was presented in most of the industries analyzed and projected into the future.

In projecting Colorado's 1970 agricultural employment, DRI first projected the outputs of major commodity groups, (such as livestock, wheat and other grains, and sugar beets) to 1970 in dollar terms, using 1960 prices. These projections were based on (1) a combination of the opinions of experts in the field of agriculture, and (2) a comparison of forecasts of U. S. production (when available) in a specific commodity and the output in that same commodity in Colorado. By analyzing past trends, the ratio of Colorado output in the commodity to U. S. production was projected to 1970.

The second step was to estimate the dollar output per worker expected by 1970. Then employment was estimated by dividing the total estimated output by the estimate of output per worker.

Four projections were made for cattle and calves. Projection No. 1 was based on the U. S. Department of Agriculture's projections on cattle and calves for the entire U. S. Colorado's projected cattle and calves on farms was obtained by using the ratio of Colorado to U. S. cattle and calves and the U. S. projected amounts of 1970. A 25% increase was projected.

Projection No. 2 was based on an extension of the past trend for Colorado of live weight of cattle and calves sold, and also indicated a 25% increase.

Projection No. 3 was based on information received from agricultural consultants and others intimately familiar with the cattle and calf situation in Colorado, especially one large Colorado feedlot producer and one of the largest meat packing companies in the Denver area. The latter two firms projected a 25% increase in Colorado marketings of cattle and calves by 1970. This projection checked very closely with Projections 1 and 2.

Projection No. 4 was also based on the opinion of knowledgeable persons in the cattle and calf industry, but their projections of the dollar value of cattle and calf marketings of 1970 were 8% below the other three projections, mainly because of a possible increase in the price of feed grain.

For sheep and lambs also, the judgment of informed individuals was relied on in making a forecast of this industry's Colorado production. A five per cent decline for 1960-70 was unanimously forecasted.

A projection of wheat marketings was made, but the method was not given.

The projection of sales of dairy milk products was based on Colorado's expected growth in population, and the trend in per capita milk consumption.

Sugar beet production was expected to increase at about the same rate as the national population increases. Also, past trends of production were projected into the future. The former statement is interesting, since 44% of the U. S. market is reserved for foreign countries.

The method of projection for other agricultural commodities (potatoes, vegetables, feed grains, hogs, and hay) was not given.

For the agricultural employment estimates (1970 output divided by output per worker), it is necessary to project output per worker. This was done, pessimistically for employment, by continuing the past rising trend. It was projected, optimistically insofar as employment is concerned, by leveling off the past trend.

The discussion of the mining industry was based upon a report prepared by Frush.[111] In projecting mining employment, the changing composition of employment in the mining industry over the past few years was noted. In considering these changes, the important developments during the past decade were noted. In making the projections, anticipated institutional and natural forces, (such as laws requiring automobile exhaust purifiers, termination of government contracts, growth of the local construction industry, technological improvements, the increased use of strip mining in coal, anticipated activation of new oil wells, increasing difficulty of further efficiency in the use of manpower in the petroleum industry, natural resource reserves, possibility of foreign competition, etc.) were considered. The exact method of projection was not given in the DRI report.

In projecting manufacturing employment, the increase in output expected by firms and the continued improvements in output per man-hour were taken into consideration. A rather detailed analysis of major manufacturing industries in Colorado was made. Industries were grouped in such a way as to preclude divulging employment figures of certain large manufacturers. The grouping was also dictated by the limitations of Bureau of Labor Statistics data, which groups industries according to the standard industrial classifications suggested by the Bureau of the Budget.

It appears that much of the analysis of meat packing was based upon the opinions of the head of one major meat packing firm. The factors he apparently considered were the anticipated increase of local markets, availability of raw material, and replacement of the relatively old plants with more modern and efficient facilities.

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[111] Charles O. Frush, "Colorado Mining History and Mining Expectations," prepared for the Industrial Economic Division of the University of Denver Research Institute, September 1962, as cited in Mahar, Coddington, and Gilmore, p. 84.

The projection of employment in the dairy products industry was based upon anticipated population growth and per capita consumption of dairy products.

The basis of the forecasts of employment in bakery products, beverages, canned and frozen foods, sugar, and all others is not clear; except that such factors as the recent construction of new facilities, continuation of past trends, opinions of representatives of major firms, the decline of employment in the agricultural industry, the anticipated growth of Colorado and regional markets, and improved production techniques were considered.

In making the forecasts of employment in textiles and apparel, the method is not clear; except that the following factors were considered: the anticipated pool of relatively low cost, adept, female workers; economical transportation to the major markets, excess productive capacity in the industry, foreign competition; and the tendency to take advantage of the western location by specializing in western-type products.

In anticipating employment in furniture and wood products, anticipated population increase in Colorado and the Mountain States was considered.

Factors which will influence employment in paper, printing and publishing are population increase, technological change, and possible construction of facilities to produce paper products.

For chemicals and allied products, consideration was given to the growth of the chemical industry nationally and Colorado's favorable location for the manufacture of drugs and other high value per pound chemical products.

The projections of employment in rubber, plastic, leather, and related products were based largely on the intentions of the two dominant firms in the state, The Gates Rubber Company and Shwayder Brothers, Inc., and the anticipated rate of technological change in the industries.

Major factors affecting future employment levels in the construction sector of stone, clay and glass include construction activity, availability of raw materials, competition from other building materials, improvements in present product lines, and new production techniques. Construction activity depends upon growth of local markets for its growth.

The Colorado Fuel and Iron Corporation with its integrated plant in Pueblo dominates the primary metals industry in Colorado. DRI's projection of employment in primary metals was based upon consideration of anticipated technological change, new products, foreign competition, and expansion of regional markets.

Anticipated employment in the defense-oriented, high value products (fabricated metal products, machinery, electrical machinery, transportation equipment, and ordnance and accessories) was based upon an analysis of the relationship of value per pound, civilian versus government market orientation, knowledge gained from contact with the major Colorado firms in these five industries, the near future market for defense and aerospace products, the success of the Martin-Marietta Corporation in attracting new contracts, the limitation by Martin-Marietta plant capacity elsewhere, its policy on Colorado employment levels, the physical limitations on the size of objects or space vehicle airframes which can be completely fabricated in Martin's Littleton plant and transported to prospective launching sites, and controls on nuclear arms production.

The projection of employment in other manufacturing (instruments and related products, petroleum refining and related products, and miscellaneous manufacturing industries) was based upon the continued ratio which employment in these industries bore to total manufacturing employment in past years.

Three major methods were tried for estimating construction employment: (1) Forecasting value of construction, divided by per man-hour output to arrive at total employment, (2) trending construction employment, and (3) continuing the ratio of construction employment as a percentage of total employment in Colorado. It was decided that, because of the limited availability of data, the last approach was the most realistic and workable. Little assumed that construction employment in the eleven Western states will remain at about the same proportion of total employment as it was in 1960.[112/] This seemed to be conservative, considering the upward U. S. trend, and the relatively rapid growth predicted for the eleven Western states. The higher the rate of population growth in a state, the more important construction employment tends to be in relation to total employment. Factors of importance should be the construction of the Interstate Highway program and the Frying Pan-Arkansas Project, continued activity in the commercial and residential construction field, generated by overall economic growth forces.

The major factors influencing the forecast of employment in the transportation, communications and utilities industry were evidence that the railroads may

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[112/] Arthur D. Little, Inc., Future Economic Growth in the West and Prospects for Rail Freight, prepared for Atchison, Topeka and Santa Fe Railway Co., Boston: A. D. Little, Inc. (1961), as cited in Mahar, Coddington, and Gilmore, p. 82.

increase their share of the markets, the expansion of "piggy backing," the growth of the West, the trends toward lowering of rates, the interstate highway program, the increased amount of cargo to be hauled, the increase in passenger and air cargo traffic, increases in population, the need for increasing transportation systems for the urban mass, technological change, competition from other carriers, the precarious financial position of many local owners of interstate carriers, the transfer from Colorado of administrative facilities of United and Continental airlines, integration of the railroads with other types of carriers, the forecasts of the dominant companies in the industries making up this group of industries, and the vertical penetration of markets via new product and service offerings.

In projecting employment in finance, insurance, and real estate, the degree of basicness of these industries was analyzed. This was done in two ways: (1) A questionnaire concerning trade area and sales outside of Colorado was sent to many of Colorado's larger financial institutions and insurance companies. (2) An analysis of the size of firm was carried out. Then the projection was based upon Colorado's expected growth, and its position as a regional financial and insurance center.

In projecting employment in wholesale and retail trade in Colorado, a questionnaire was sent to 160 firms in the wholesale trade industry, asking the firms to describe their primary trade area and to indicate what portion of their business was carried out in Colorado. An analysis was made of the individual items contained in the general category of retail trade to indicate in which ones tourism had a significant impact. In forecasting retail and wholesale trade in Colorado, employment was divided into two parts, each of which was treated separately. The first part consisted of the surplus persons who may be accounted for by tourism and by wholesale trade outside Colorado. This employment was considered basic and independent of general employment levels in Colorado. The remainder of the wholesale and retail trade category was forecasted using a ratio approach, estimating the portion of Colorado employment that will be in the nonbasic wholesale and retail trade in 1970.

In estimating employment in the basic sectors of trade, trends in tourism and travel were discussed. These indicators were changes in tourism which were based on payments for admission, licenses, and other accounting records; visitors from out-of-state found in the Traffic Volume Studies of the Colorado Highway Department; and the count of visitors to Colorado's National Parks. The Outdoor Recreation Resources Review Commission's estimate of the nation-wide demand for outdoor recreation facilities was used. The U. S. Forest Service has made estimates of the effect of this demand on its Colorado facilities, and on other facilities located on its Colorado land. This was done partially by making estimates of future visits. In making predictions concerning tourism, one would have to estimate the facilities that would be available, the development of transportation routes to these facilities, and the amount and effectiveness of promotion.

The population and total income increase of Wyoming, Colorado, and New Mexico (a common trade area served by many Colorado firms) was estimated by Little.[113/] On the basis of the favorable expectations for both the tourist industry and for Colorado's distribution firms serving out-of-state areas, DRI estimated the increase in the so-called surplus jobs in wholesale and retail trade.

It was assumed that Colorado trade employment will follow the national pattern, and estimated that employment in the non-basic portion of trade will increase in importance by one-half of one per cent of total employment. They then combined the basic and non-basic portions in making their projection of total employment in wholesale and retail trade.

Three studies prepared for the Resources and Community Development Division of the Colorado Department of Employment by the Denver Research Institute showed that Colorado is a favorable location for research and development laboratories, medical research activities, and administrative headquarters and regional offices.[114/] DRI appears to have projected past trends in Colorado for their employment projections in the service industry as their optimistic projection, and to have taken the Stanford Research Institute prediction of a leveling off of the ratio of Colorado employment in services to U. S. employment in services as their conservative prediction.

In projecting employment in government, no forecast was attempted for the number of military personnel stationed in Colorado. It was assumed that Federal employment would continue to increase at the trend of recent years. A straight-line

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[113/] Ibid.

[114/] Denver Research Institute, An Analysis of Colorado as a Location for Industry (a series prepared for the Colorado Department of Employment) (1959-1962); Projections of Employment In Metropolitan Denver to 1980 and 2000 (prepared for the Board of Water Commissioners, City and County of Denver) (1958); and Economic Significance of a Shale Oil Industry in Northwestern Colorado (prepared for the Committee on Oil Shale Development) (1957), Denver: Denver Research Institute.

extrapolation of State employment apparently was used. Employment projections in local government was based upon anticipated growth in school enrollment and apparently a straight-line extrapolation of growth in employment in municipal and county government and service areas. The projection of school enrollment was based upon the population of children of parents presently living in Colorado and a continuation of the recent in-migration trend.

Employment projections in "other" employment (all nonclassifiable employment) was made on the basis of the continuation of the trend of the ratio of this type of employment to total employment, as its optimistic prediction; and a continuation of the present ratio as its pessimistic prediction.

In making the total Colorado employment projections to 1970, the individual forecasts were drawn together. In the opinion of the Research Director of the National Planning Association, employment and population tend to be underestimated in economic studies of individual states. The NPA approach is to make first an estimate of economic activity in the United States, and then allocate it state by state. Little states that nothing is foreseen in the near future which will replace the aerospace industries in stimulating the growth of the Western United States. His assumptions concerning the U. S. economy are very similar to those used by the Denver Research Institute.

The Denver Research Institute made conservative, optimistic, and most probable estimates. The most probable estimate represented their opinion of where Colorado employment is most likely to be in 1970.

Major reliance was placed upon employment data as the primary measure of economic activity. Employment estimates, along with estimates of the labor participation rate, provided the basis for the population estimates. Other methods for estimating population are the Cohort Survival Method, trend projections, and the use of ratios. The Cohort Survival Method gives detailed consideration to birth, death, and migration rates and is used by the Bureau of the Census in making its estimates. These methods do not take advantage of the detailed economic data developed in the DRI analysis and were used only as background checks.

The labor participation rate in 1970 in Colorado and the United States was assumed to decline due to continuation of the downward trend in proportion to the percentage of people in the age group 16-64. "Labor participation rate" meant the percentage of the population actually employed rather than the percentage that the labor force was of population.

It was assumed that the trend toward a greater concentration of the population in urban and metropolitan areas would continue.

Colorado income projections were made by (1) estimating 1970 income per employee in 1960 prices for each industry, (2) multiplying the most probable number of employees times income per employee, and (3) adjusting from industrial sources of income to total personal income. Future income levels in each industry were estimated by the Denver Research Institute, income levels per worker were estimated; and total personal income in Colorado was calculated.

In accomplishing the study, the many sources of employment information were evaluated, and then the combination was selected which was the most useful. An historical employment series from 1870 to 1940 was constructed. Perloff's data was used for total employment, agriculture, and mining. Census reports, without adjustment, were used for data for construction, transportation, and industries other than manufacturing for 1930 and 1940. An employment series, based upon establishment data, was constructed for manufacturing which would give a breakdown of activity within manufacturing. This was done by going through the original Census reports, making the Easterlin corrections, and then labeling each type of activity in accordance with the present Standard Industrial Classification system.[115]

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[115] Easterlin developed a technique for adjusting the data in the decennial Census of Manufactures for Census-to-Census consistency. His corrections of manufacturing data are of three general types. "The first corrects for the inclusion in manufacturing in the 1880's of such activities as carpentry, masonry, painting, paper hanging, plastering, stucco work, and other types of construction work. Easterlin suggested removing these activities from manufacturing in order to make the manufacturing series consistent with today's definition.

"Easterlin's second correction deals with the fact that, in the 1880's and earlier, much manufacturing was done in the home in the form of handicrafts. An effort was made as early as 1849 to exclude small handicrafts by omitting from the Census any firm which produced $500 or less in value each year. In 1919 the minimum was raised to $5,000. This step eliminated many bakeries, blacksmith shops, boots and shows (custom and repair shops) and clothing repair shops, as well as many handicraft operations. During this period, the Census made an effort to limit its counts to what it called 'factories.' By its definition, 'The essential difference between factories and neighborhood establishments seems to be that the products of factories are distributed beyond the narrow limits of the communities in which they are located, while the products of neighborhood establishments are consumed by local patrons.' This is termed 'production for the general market.' This concept, combined with the minimum dollar limit, excluded many previously counted firms.

"The third Easterlin correction relates to industries covered intermittently during the period 1870 to 1940. This included auto repairing, railroad car

According to DRI, there are five groups which presently report employment data for the State of Colorado: (1) Colorado Department of Employment, (2) County Business Patterns, (3) U. S. Bureau of Labor Statistics, (4) U. S. Bureau of the Census, and (5) U. S. Census of Agriculture. The Denver Research Institute derived its current employment series from the following sources:

The total employment figures for 1950 and 1960 are the same as those reported in the 1950 Census of Population and the 1960 Census of Population. For agriculture, for 1950 and 1960, the figures reported in the 1950 Census of Population and the 1960 Census of Population were used. The Colorado Department of Employment records of seasonal employment were used for certain of the projections that required data on part-time agricultural employment. For the intervening years, 1951-1959, and for 1961 and 1962, the Colorado Department of Employment constructed an agricultural employment series for Colorado.

DRI utilized an Agricultural Marketing Service publication which presents data on the fluctuations of farm employment in Colorado. It felt that the AMS series was useful to show fluctuations and by tying them to the bench mark years of 1950 and 1960, it was possible for the Department of Employment to construct an agricultural employment series for use in this study.

For mining, the 1950 and 1960 data came from the 1950 Census of Population and the 1960 Census of Population. For the intervening years, BLS data was used as indicators of fluctuation. The years 1950 and 1960 served as a bench mark for the intervening years and the BLS employment information served as the basis for calculations from 1951-1959 and 1961-1962. Ratios were used to adjust BLS data for use in the DRI employment series.

The manufacturing series consisted of BLS data entirely. Construction was treated the same way that mining was. Transportation and communications and public utilities were treated the same as manufacturing. Wholesale and retail trade and finance, insurance, and real estate were treated the same as mining; and government, the same as manufacturing. In services, the 1950 and 1960 data were obtained by a residual technique. It was figured by subtracting from the BLS total employment figure all employment in the other industries. The data for the

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maintenance, illuminating and heating gas, motion pictures, and others." Quoted from Mahar, Coddington, and Gilmore, *op. cit.*, p. 169. See also Everett S. Lee, *et al.*, *Population Redistribution and Economic Growth in the United States, 1870-1950*, Philadelphia: The American Philosophical Society (1957).

intervening years was calculated by the same technique as used for mining. The 1950 and 1960 "other" nonclassification employment figures were taken directly from the 1950 Census of Population "other" employment and the 1960 Census of Population "other" employment. For the intervening years, the same technique was used for mining.

Public Service Company of Colorado[116]

The Public Service Company of Colorado has published an undated pamphlet in which it summarizes the work of the Denver Research Institute, and then proceeds to suggest an historical approach which cuts across the conventional Standard Industrial Classification groupings.

The pamphlet reviews the reasons for the three population surges in Colorado, the search for precious metals from 1850 to 1900, the homesteaders from 1900 to 1940, and the post-World War II immigration. It contends that population growth in Colorado historically has been related to employment opportunities. After listing Colorado's basic industries (mining, manufacturing, agriculture, Federal government, and tourism), it describes briefly the historical growth or decline of each industrial group, giving projections for the future.

Then, contending that the conventional or standard approach does not clearly expose some underlying factors important to the future of the state, it suggests that several factors of the Colorado economy which cut across the conventional industrial groupings show particularly happy prospects for the future. These factors are Colorado's scientific community, the state's position as an economic hub, and the underlying importance of natural resources.

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[116] An Analysis of Colorado's Economy With Projections to 1970, op. cit.

APPENDIX I-b

DATA AVAILABLE FOR MAKING EMPLOYMENT PROJECTIONS IN THE DENVER SMSA

EMPLOYMENT-BY-INDUSTRY DATA

The main sources of employment-by-industry data for the Denver Standard Metropolitan Statistical area are the data from the Bureau of Labor Statistics, the Bureau of the Census, the Colorado Department of Employment, and the Social Security Administration.

Bureau of Labor Statistics

Employment-by-industry data available from the Bureau of Labor Statistics for the Denver Standard Metropolitan Statistical Area can be found in the BLS publications showing employment, hours and earnings in those industries the establishments of which report their payroll data monthly to the Bureau of Labor Statistics.

The Bureau of Labor Statistics data are supplied by employers, voluntarily, to the State agencies cooperating with the Bureau of Labor Statistics. In its reports, the designation "all employees" means all full-time and part-time employees on the payrolls of operating establishments who work or receive pay for any part of the pay period ending nearest the fifteenth of the month specified in the report form. However, the data exclude domestic servants, firm members, members of the armed forces, proprietors, self-employed persons, unpaid family workers, and employment in agricultural, forestry, and fisheries.

No statistics were published for "total" nonagricultural employment (keeping the above exclusions in mind) for the Denver area before 1954. All data published by the Bureau of Labor Statistics before 1958 for the Denver area were for the Denver Standard Metropolitan Area (SMA) rather than for the Denver Standard Metropolitan Statistical Area (SMSA). The Denver Standard Metropolitan Area (SMA) included four counties -- Adams, Arapahoe, Denver, and Jefferson. Data for the City of Denver are the same as for the County of Denver since they constitute the same geographical entity. The Denver Standard Metropolitan Statistical Area is the Bureau of the Budget geographical designation for statistical purposes which came into being on January 1, 1958. On that date, Boulder County was added to the Denver area and the official designation changed from the Denver Standard Metropolitan Area (SMA) to the Denver Standard Metropolitan Statistical Area (SMSA).

The first data published for the SMA by the Bureau of Labor Statistics was for 1949 in Employment, Hours, and Earnings: State and Area Data, Volume I, Area Employment, 1950.[1] This publication shows SMA employment, monthly and an annual average, for 1949 for six nonagricultural sectors.

Employment, Hours and Earnings: State and Area Data, 1947-51, shows Denver SMA employment (excluding proprietors, firm members, self-employed, domestic servants, members of the Armed Forces, and unpaid family workers) for six nonagricultural sectors for 1949, 1950, and 1951. Current state and area statistics were published monthly by state agencies and were summarized by the Bureau of Labor Statistics in its monthly reports "Employment and Payrolls," and "Hours and Earnings."[2]

The monthly "Employment and Earnings" releases of the Denver Office of the Bureau of Labor Statistics have been current since 1949.[3] These releases did not include employment for government and non-profit organizations in 1949 or 1950, nor for government in 1951, 1952, or 1953. Therefore, no figure is available for total (with the usual exceptions) nonagricultural employment even for the SMA before 1954. With these exceptions, employment was shown for forty sectors or subsectors for the Denver Standard Metropolitan Area (SMA) for the years 1949-1957. A new series was started in 1958, which included Boulder County and which had some different sector designations than the previous series. They show monthly SMSA data and annual averages for total nonagricultural employment (with the usual exclusions) in 53 nonagricultural employment categories. The releases also include monthly data on average weekly earnings, average hours worked per week, and average hourly earnings for twelve industries.

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[1] Employment, Hours, and Earnings: State and Area Data, Volume I, Area Employment, 1950, U. S. Department of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office (1950).

[2] Employment, Hours and Earnings: State and Area Data, 1947-51, U. S. Department of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office (1952).

[3] U. S. Department of Labor, Bureau of Labor Statistics, Denver.

Employment and Earnings is a monthly, current publication showing area data on employment by major industry division, and hours and earnings and labor turnover for manufacturing.[4] The first data available are for January 1950, shown in the January 1951 number. The number of categories included has varied from six to nine, and there has not always been a continuous series of any particular category published. In May 1954, the publication included the Employment and Payrolls Monthly Statistical Report series.[5] The January 1951 issue started with six categories -- mining, construction, manufacturing, transportation, trade, and finance. The coverage included "service" in the 1954 issue; and in the November 1954 issue "government" and "total" figures were added.

Employment and Earnings Statistics for States and Areas 1939-1963 shows Denver SMSA employment (excluding proprietors, self-employed, domestic servants, members of the Armed Forces, unpaid family workers, and employment in agriculture, forestry, and fisheries) for 42 nonagricultural sectors, generally from 1958.[6] It also shows average weekly earnings, average weekly hours, and average hourly earnings for production or nonsupervisory workers for eleven sectors generally from 1958, but in some cases from 1951 or 1953. "Month-to-month changes in employment shown by the reporting establishments in each industry are used to carry forward a total for the industry estimated for a single month each year -- a 'benchmark.' Each year the industry employment series for states and areas are adjusted to more recent benchmarks."[7] The data are based upon the 1957 Standard Industrial Classification.

Bureau of the Census

The Bureau of the Census in the United States Department of Commerce publishes the most detailed employment statistics for the Denver Metropolitan

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[4] Employment and Earnings, U. S. Department of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office (continuing series).

[5] Employment and Payrolls Monthly Statistical Report, U. S. Department of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office.

[6] Employment and Earnings Statistics for States and Areas 1939-1963, U. S. Department of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office (1964).

[7] Ibid., p. v.

Statistical Area or the geographical entities which comprise it. The following publications are available: Annual Survey of Manufactures, Census of Agriculture, Census of Business, Census of Manufactures, Census of Mineral Industries, and Census of Population.[8]

The following secondary sources take their information in whole or in part from the publications of the Bureau of the Census: Congressional District Data Book, County and City Data Book, Historical Statistics of the United States, and Statistical Abstract of the United States.[9] In addition, unpublished data are available, usually at considerable expense, from all of the primary sources, as well as the Census of Governments, Civil Service Commission reports, and the Monthly Report on the Labor Force.[10] The Census of Governments contains employment figures of Federal, state and local government, but on a state-wide basis, making them difficult to use for SMSA analysis. The Civil Service Commission publishes each December the number of people employed in the classified civil service in each state. The Monthly Report on the Labor Force each month contains employment and related data on a national basis.

Of the primary sources, the Census of Population provides household data; all the others provide establishment data. Household data means that the information was obtained from the place the person lived, rather than where he worked, and is reported on that basis. Employment data gathered in this manner, therefore, measure the number of persons employed; whereas establishment data, being gathered from employers, measure the number of jobs.

This has several important implications. In a particular area at any time, there may be more jobs in establishment data than persons employed in household data. Conversely, there may be fewer jobs in establishment data than persons employed in household data. There can be more jobs than persons if a considerable number of persons hold more than one job. There can be more persons employed in household data than jobs in establishment data if a considerable number of people are temporarily not working due to industrial disputes, a slack season, self-imposed vacations, etc. These persons are counted as employed in the Census of Population data, but not in the data which are reported by establishment. Also, a person who lives in Boulder County and works in Denver County is included in the statistics for Boulder County in Census of Population data but in the statistics for Denver County in establishment data. This difference between the two sources of data has even greater significance if a person lives in the SMSA, but works outside the SMSA, or vice versa. In household data, persons who are employed by government, but working in manufacturing or service, are included in the data in the industrial category in which they are working. In establishment data, they are not included in the industrial sector, but are included in a category called "Government."

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[8] Annual Survey of Manufactures; Census of Agriculture; Census of Business; Census of Manufactures; Census of Mineral Industries; Census of Population, U. S. Department of Commerce, Bureau of the Census, Washington: U. S. Government Printing Office.

[9] Congressional District Data Book; County and City Data Book; Historical Statistics of the United States; Statistical Abstract of the United States, U. S. Department of Commerce, Bureau of the Census, Washington: U. S. Government Printing Office.

[10] Census of Governments, U. S. Department of Commerce, Bureau of the Census, and Monthly Report on the Labor Force, U. S. Department of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office (continuing series).

The Annual Survey of Manufactures is a supplement to the Census of Manufactures and in one or the other of the 1956, 1957, 1960, and 1963 editions can be found employment data for the Denver SMSA for from six to eight manufacturing sectors for the years 1947 and 1954-1962. Data are published for number of employees, number of production workers, and man hours of production workers. The data are collected from all manufacturing establishments in census years and published in the Census of Manufactures. Data are collected from a probability sample of manufacturing establishments in the inter-censal years and published in the Annual Survey. Annual employment averages are based on employment of production workers during the pay period ending nearest the fifteenth of March, May, August and November, and mid-March employment for "all other employees." "All employees" are defined as all full-time and part-time employees on the payrolls of manufacturing establishments who work or receive pay for any part of the mid-month pay period. However, the summary does not include establishments employing fewer than 100 persons.

The Census of Agriculture in recent years has been taken in Colorado as of January 1, 1945; April 1, 1950; October 1954; and November 1959. It shows the number of farm operators and hired workers by county. Censuses of agriculture have been taken since 1840, and in mid-decimal years since 1925.

The Census of Business is made up of three volumes, one on retail trade, one on wholesale trade, and one on selected services. The volume on retail trade gives data on the number of establishments, sales, payroll, employment, and number of proprietors of unincorporated businesses for the standard metropolitan statistical area by 95 kinds of businesses; and for counties by varied kind-of-business detail. The volume on wholesale trade gives data on the number of establishments, sales, payroll, employment and number of proprietors of unincorporated businesses for the standard metropolitan statistical area for 58 kinds of business, and various business detail for counties. The volume on selected services gives data for selected services for the standard metropolitan statistical area and for counties. The Census of Business shows the number of paid employees during the work week ended nearest November 15, as well as the number of active proprietors of unincorporated businesses for SIC 4-digit sectors in retail and wholesale trade and selected services. It has shown this information for counties in 1948, 1954, and 1958; for the Denver SMA in 1945 and 1954; and for the Denver SMSA in 1958. The retail sales figures differ from the Colorado Department of Revenue figures because the state collects sales tax on lodging, professional services, public utility services, farm and garden supplies, and manufacturing, trading, and jobbing.

The 1958 Census of Business showed for 2-, 3-, and 4-digit industries for the SMSA in 121 categories the total number of establishments, the number of establishments with payroll, total sales, the payroll for the entire year, the payroll for the work week ended nearest November 15, the number of paid employees during the work week ended nearest November 15, and the number of active proprietors of unincorporated businesses.

The 1954 Census of Business showed employment data for 2-, 3-, and 4-digit industries in 95 categories for the Denver SMA and 42 categories for Boulder County, the county that was not included in the SMA in 1954, but was included in the SMSA in 1958.

The 1948 Census of Business showed retail trade data in 100 categories for the SMA and 30 categories for Boulder County, wholesale trade data in 100 categories for the SMA and one category for Boulder County, selected services data in 100 categories for the SMA and seven categories for Boulder County.

The Census of Manufactures shows the number of employees, value added by manufacture, and other data for 59 industry groups in 2- and 3-digit detail, except that industry groups reporting less than 100 employees are omitted from the 3-digit lines, and some figures are withheld to avoid disclosing figures for individual companies. Detail is given for the SMSA for 1947, 1954, and 1958; for the SMA for 1954; and for counties for 1939 and 1947.

The Census of Mineral Industries, covering all establishments primarily engaged in mining, provides data on the number of employees, value added in mining, payrolls, man hours of production and development workers, and other data for counties for 1958 and some data for the counties of the SMSA for 1954. The categories among the counties in 1954 are not comparable. For example, employment is shown for Adams County for oil and gas extraction and nonmetallic minerals mining; but for Arapahoe County for mineral industries only. Federal, state, and local government production in minerals are excluded.

The Census of Population is the dominant source of employment data, being the only source which covers all (except those under 14 years of age and some part-time workers) employed persons in the population, and is the source providing more data in depth (industrial classification detail) than any other source.

The Census of Population has been published decennially since 1790. In recent years, employment by industry has been shown for each county in varying amounts of detail for 1930, 1940, 1950, and 1960. The detail for Denver County is greater than the other counties. SMA data were shown in great detail in the 1950 census, and SMSA data were shown in great detail in the 1960 census.

In the census enumeration, each person is counted as an inhabitant of his usual place of residence, which generally means where he sleeps most of the time. College students are considered residents of the communities in which they reside while attending college. This is a change from the 1940 census when they were considered temporarily away from their parental home.

In the 1950 and 1960 censuses, although April 1 was the official date of the censuses, most (91%) of the population was enumerated during the first half of April. Hence the report of employment activity may be as of the last week in March for some, as of the second week in April for others, and as of any week starting with Sunday and ending with Saturday, between March 24 and April 15 for still others. In the 1940 census, the data refer to a fixed week (March 24-30), called the "census week," regardless of the date of enumeration.

In the census, "employed persons" refers to civilian employment, and means all civilians 14 years old and over who during the census week were either at work, which means "those who did any work for pay or profit, or worked without pay for 15 hours or more on a family farm or in a family business;" or with a job but not at work, which means "those who did not work and were not looking for work but had a job or business from which they were temporarily absent because of vacation, illness, industrial dispute," or some other temporary reason.[11]

The industrial classification system of the 1950 Census of Population consists of 13 major industry groups, disaggregated into 148 categories. The Census of Population industrial classification is not the same as the Standard Industrial Classification. The latter was designed for the classification of the industry reports from establishments. Perhaps the most significant difference in the statistics reported under the two systems is allocation of government workers. The SIC relegates all government workers to a single major group, called "Government," while the Census of Population records in a category called "Public Administration" only those governmental workers who are performing uniquely governmental functions (the legislative and judicial activities and most of the activities of the executive agencies). The rest of the government workers are placed by census in the specific industrial categories in which they are actually performing.

The industrial classification system of the 1960 Census of Population consists of 13 major industry groups, disaggregated into 40 industry groups and 150 categories.

The industrial classification system which was used in 1940 was basically the same as in 1950.

"Class of worker" information refers to the same job as does the occupation and industry information. The class-of-worker classification consists of four categories -- self-employed workers, government workers, private wage and salary workers, and unpaid family workers. The omission from the labor force of a large number of workers (mainly youth, women, and part-time workers), has probably resulted in some understatement in many of the occupational, industrial and class-of-worker figures.

The data on the labor force for 1940, 1950, and 1960 are not exactly comparable with the 1930 data. The number of employed persons in the 1940, 1950, and 1960 censuses differ from the number of those "gainfully occupied" in the

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[11] U. S. Census of Population: 1960, General Social and Economic Characteristics, Colorado, Final Report PC(1)7C, U. S. Department of Commerce, Bureau of the Census, Washington: U. S. Government Printing Office (1961), p. xix.

1920 and 1930 censuses. In 1920 and 1930, "gainful workers" were persons reported as having a gainful occupation -- that is, an occupation in which they earned money or a money equivalent, or in which they assisted in the production of marketable goods regardless of whether they were employed currently or seeking employment in that occupation at the time of the census. A person could have worked at one time as an accountant, call himself an accountant, be working as warehouse laborer or even be retired; but he would be enumerated as an accountant if he called himself an accountant. This is what is known as the "gainful worker" concept which is frequently mentioned, but rarely explained. Furthermore, in the 1930 census and before, all workers ten years old and over were included in the labor force. Since that time, only those 14 years old and over have been included.

For the most part, the 1940, 1950, and 1960 censuses are comparable with one another, despite changes in schedule design and the interviewing techniques for the labor force questions.

The occupational and industrial classification systems of the 1940 and 1950 censuses are basically the same as those of 1960, although there are some differences between the 1940, 1950, and 1960 classification systems.

Comparisons between census data and data from other sources should be made with caution for three main reasons. (1) Census of Population data are household data. Most other data are establishment data. Since Census of Population employment data are obtained by household interview, they differ from statistics based on reports from business establishments, farm enterprises, and certain governmental units. The data based on household interviews give information about the work status of the whole population without duplication. On the other hand, estimates based on reports from business and farm establishments count more than once persons who worked for more than one establishment. Persons who had a job, but who were not presently working, are included with the employed in the statistics shown in the census, whereas many of these persons are likely to be excluded from employment figures based on establishment payroll reports. Furthermore, because of the difference in the collection of establishment and household data, comparisons are difficult where a significant number of workers commute to or from other areas. (2) Comparability between the Census of Population statistics and those from other sources is frequently affected by the use of different classification systems. The Census of Population has its own classification system, whereas most other sources use the

Standard Industrial Classification system. (3) Estimates from other sources generally exclude private household workers, unpaid family workers, self-employed persons, and other groups of workers; and may include workers less than 14 years of age.

The Current Population Survey, which has been conducted since 1940, covers a sample of 35,000 households throughout the nation. It provides only national estimates of the employment status of the population. Conducted by the Bureau of the Census, it provides monthly statistics on population, employment, and related subjects. Although the Current Population Survey is subject to greater sampling variability than the Census of Population, its interviewers are more professional and experienced than the Census of Population enumerators. In some small areas in the decennial census, the enumeration is conducted by an exceptionally small number (often only one or two) enumerators, who are usually temporary workers adding to the family income decennially. For this reason, many analysts have more faith in the validity of the Current Population Survey data than those from the census. The population data compiled from the Current Population Survey are analyzed by the Bureau of the Census and published in *Current Population Reports*; the employment data are analyzed by the Bureau of Labor Statistics, and published in the *Monthly Report on the Labor Force*, and, subsequently, in *Employment and Earnings*.[12/]

The figures on the labor force in the Census of Population are not the same as those reported in *Current Population Reports* for the same month. The Current Population Survey of April 1950 showed six per cent more people in the civilian labor force than shown in the preliminary 1950 Census of Population report. After examination, it was estimated that the 1950 census figures of the population 14 years old and over should be increased by probably three per cent to be more in accord with reality. Of course, a specified percentage adjustment for the total national labor force cannot be applied to detailed industry categories in local area statistics without some misgiving.

The steps taken in the collection and processing of data in the 1940, 1950, and 1960 censuses differed somewhat from each other. For example, the so-called "main activity" question of 1950, "What was this person doing most of last week -- working, keeping house, or something else?" was not included in the 1960

[12/] *The Monthly Report on the Labor Force*; *Employment and Earnings*, U. S. Department of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office (continuing series).

schedule. This was an initial screening question used in 1950 to facilitate asking additional questions on the employment status of the individual.

In all parts of the United States a few days before the 1960 census date (April 1), households received by mail a questionnaire entitled "Advance Census Report" (ACR) containing the questions which were to be answered by all persons and instructions for completing the form. In the densely-populated areas, of which the City and County of Denver was one, a second-stage enumeration procedure was used, on a 25 per cent sample basis, to supplement the information obtained from the enumeration of the total population. In these areas, when the enumerator called to collect the ACR, he left at every fourth household a questionnaire to be filled and mailed to the local census office. In the less-populated areas, the sample questions were asked by direct interview. The statistics based on this 25 per cent sample of the entire population were published in Chapters C and D of the 1960 Census report, Characteristics of the Population, and in some of the tract report tables. In addition, approximately one-fifth of these cases were selected for the 5 per cent sample used in all the Volume II subject matter reports.

In computing the 1960 census, the heavy reliance on electronic equipment has improved the quality of the editing of the census reports, but at the same time has introduced an element of difference between the 1960 statistics and those of earlier years. The partial substitution of self-enumeration in the 1960 census for the traditional direct interview made it feasible to call the respondent's attention more uniformly to some of the important inclusions and exclusions in the definitions, but even so it was not feasible to give the full instructions to the respondents and some of their errors have undoubtedly gone undetected.

Both human and mechanical errors occasionally arise in one form or another in any mass statistical operation such as census; for example, information might be recorded in the wrong place, causing inconsistencies between codes on interrelated items. Although it is impossible to know the number of errors in the earlier censuses, much can be learned from editing the 1960 census. Elimination of card-punching has removed one important source of error.

Colorado Department of Employment

The Colorado Department of Employment data include only employment covered by the Colorado Unemployment Compensation Act and the Unemployment Compensation for Federal Employees program. The statistics for workers in private industry include employment of all corporation officials, executives, supervisory personnel, clerical workers, wage earners, part-time workers, persons on paid vacations, and piece workers. However, they exclude the following: (1) domestics in private households, farm workers, proprietors, the self-employed, and unpaid family workers, (2) workers who earned no wages during the entire applicable pay period because of illness, strikes or work stoppages, temporary layoffs, or unpaid vacations, and (3) workers who earned wages during the month without earning any during the applicable pay period.

In the nation, this meant that the U. S. totals of State Department of Employment figures during July-September 1962 excluded approximately 30 million persons, including 2.1 million agricultural laborers; 2.6 million self-employed farmers and unpaid family workers; 6.2 million nonagricultural self-employed persons; 6.2 million state and local government workers; 6.4 million workers employed in private homes and by nonprofit religious, charitable, scientific, and educational organizations; 2.8 million members of the Armed Forces; 1.7 million workers in small firms in states (including Colorado) which do not cover establishments with fewer than four workers; and 0.9 million workers covered by the railroad unemployment insurance system.

To help compensate for these exclusions, estimates of employment and wages for nonreporting private employers and Federal installations are made by the state departments of employment and included in each quarterly report to the U. S. Bureau of Employment Security.

Employment data have been classified by industry since 1938. From 1938 through 1941, the industry classification of the 1939 edition of the *Social Security Board Industrial Classification Code* was used.[13/] From 1942 through 1946, the 1942 edition of the *Social Security Board Industrial Classification Code* was used.[14/] From 1947 through 1957, the 1942 edition of the *Social Security Board Industrial Classification Code* continued to be used for nonmanufacturing industries, and the 1945 edition of the *Standard Industrial*

[13/] *Social Security Board Industrial Classification Code*, Social Security Board, Washington: U. S. Government Printing Office (1939).

[14/] *Social Security Board Industrial Classification Code*, Social Security Board, Washington: U. S. Government Printing Office (1942).

Classification Manual was used for manufacturing industries.[15] Since January 1958, the 1957 edition of the Standard Industrial Classification Manual has been used for all industries.[16]

The unpublished data which can be obtained from the Colorado Department of Employment represent the largest universe of monthly employment and quarterly wage information by industry and by county available. According to the U. S. Bureau of Employment Security, by implication when it writes of its national data, the Colorado Department of Employment figures may be used to measure month-to-month trends, and in most cases to compare one industry with another, with assurance that such comparisons are valid.

The data of the Colorado Department of Employment are available, in varying detail and for varying periods, in three forms. IBM cards show monthly employment by establishments coded by 3-digit industry (4-digit for manufacturing), quarterly wages by establishment, and new hires, by county for 1962 and 1963. Print-outs show the number of employees, new hires, the number of employers, and quarterly payrolls for 2-digit industries from 1952 to 1957 and for 3-digit industries from 1958 to 1962, by county. Its publication Labor Market Highlights shows for the SMSA the total civilian work force, employment in 16 categories, the number of unemployed, and the number involved in labor disputes.[17] Most of the figures for this monthly publication are nonagricultural wage and salary, and come from the Bureau of Labor Statistics. The number of agricultural workers is estimated and the number of "all other" employment is estimated by a formula dictated by the Bureau of Employment Security in Washington, based upon national changes in the "all other" category during the previous month.

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[15] Standard Industrial Classification Manual, Executive Office of the President, Bureau of the Budget, Washington: U. S. Government Printing Office (1945), as referred to in Employment and Wages, U. S. Department of Labor, Bureau of Employment Security, Washington: U. S. Government Printing Office (Third Quarter 1962), p. 88.

[16] Standard Industrial Classification Manual, Executive Office of the President, Bureau of the Budget, Washington: U. S. Government Printing Office (1945).

[17] Labor Market Highlights, Colorado Department of Employment, Denver: Colorado Department of Employment (continuing series).

County Business Patterns

County Business Patterns[18/] contains figures for the number of employees during the mid-March pay period, the January-March payrolls subject to the Social Security Tax (the Federal Insurance Contributions Act tax), the number of reporting units, and the number of reporting units by employment-size class, for approximately 70 2-digit SIC industries for the Denver Standard Metropolitan Statistical Area, and for 4-digit industries of varying numbers for the counties of the SMSA. The employment counts exclude farm workers, members of the Armed Forces, domestic workers, all Federal civilian employees not covered and most of those covered under a Federal retirement system, employees on ocean-borne vessels, railroad employment subject to the Railroad Retirement Act, self-employed workers, and employees of state and local governments.

The figures are derived from the reports by employers to the Social Security Administration for old-age, survivors, and disability insurance (OASDI). The data include all wage and salary employment of nonfarm industrial and commercial employers and nonprofit membership organizations (operated for the promotion of the interests of their members) covered by OASDI; and employment of religious, charitable, educational, and other nonprofit organizations which voluntarily participate in the old-age, survivors, and disability insurance program.

A reporting unit is an establishment or a group of similar establishments operated by one employer. Taxable payrolls represent only the amount of taxable wages paid for covered employment during the quarter.

The differences in employment coverage between the OASDI data and the Colorado Department of Employment data are due primarily to the exclusion of small firms from the Colorado unemployment compensation program, differences in methods of processing and adjusting the data, and differences in inclusion of Federal employment. The Colorado Department of Employment data include all Federal agencies having employees participating in the Unemployment Compensation for Federal Employees program (Title XV of the Social Security Act), except the Central Intelligence Agency and the National Security Agency.

[18/] County Business Patterns, U. S. Department of Commerce, Bureau of the Census, Washington: U. S. Government Printing Office.

In summary, payroll data are available from the Bureau of Labor Statistics, census data from the Bureau of the Census, unemployment compensation data from the Colorado Department of Employment, and Social Security data from County Business Patterns. The Census of Population contains household data; all of the other publications containing employment statistics show establishment data. The Census of Population data cover the largest number of persons; all of the other publications exclude certain large groups of persons. The Census of Population has its own classification system; the others use the Standard Industrial Classification.

In addition to the primary and secondary sources of employment data for the Denver Standard Metropolitan Statistical Area, described above, data are also available from the Denver Planning Office and from a study made by Robert Vaughan, mimeographed in two pieces, Denver Metropolitan Area: Economic and Social Profile and Denver Metropolitan Area: Jobs and the Future.[19/] Most of the data in these two publications are secondary in that Vaughan has gone through the 1950 and 1960 censuses of population and extracted social and economic data relevant to the Denver SMSA. In addition to the Census of Population data, Vaughan has projected employment by industry and by occupation to 1970, as described above.

EMPLOYMENT-BY-OCCUPATION DATA

Employment-by-occupation data are available from the Census of Population, the Denver Area Skill Survey, and the Denver Occupational Wage Surveys. In addition, unpublished data might be obtained from the Bureau of the Census, the Bureau of Labor Statistics, the Civil Service Commission, Federal regulatory agencies, the Department of Health, Education and Welfare, local and state licensure agencies, and local and state professional societies.

Census of Population

The Census of Population is the only comprehensive source of occupational employment data.

[19/] Robert Vaughan, Denver Metropolitan Area: Economic and Social Profile; and Denver Metropolitan Area: Jobs and the Future, Denver: Mountain States Telephone Company (1962).

The occupational classification system of the *1950 Census of Population* consists of 469 items, 270 of which are specific occupation categories. The remainder are subgroupings of 13 of the occupations, mainly on the basis of industry-affiliation.

The occupational classification system of the *1960 Census of Population* consists of 479 items, 297 of which are specific occupational categories. The remainder are subgroupings of 13 of the occupations, mainly on the basis of industry-affiliation.

It should be noted that, in the Census of Population classification systems, the industry category "agriculture" is somewhat more inclusive than the total of the two major occupation groups, "farmers and farm managers" and "farm laborers and foremen," since it includes other occupations such as accountants, natural scientists, designers and draftsmen, etc.

The occupational classification of the Census of Population is generally the same as the system provided in the U. S. Bureau of Employment Security's *Dictionary of Occupational Titles*,[20/] used in the operation of the public employment service and by the military in its classification of civilian occupations. For many years, however, the U. S. Bureau of Employment Security and the Bureau of the Census have been trying to synthesize the two classification systems. The Bureau of Employment Security has released the new *Dictionary of Occupational Titles*.

Employment by detailed occupation is shown for the SMA in 1950 and for the SMSA in 1960. Employment by occupational group (for example, professional, technical, and kindred workers) is shown for Boulder County for 1950 and 1960. Employment by occupational group by industry (a cross-tabulation of, for example, professional, technical, and kindred workers in agriculture, forestry, and fisheries) is shown for the SMA in 1950. Finally, in 1960 alone, data are shown for detailed occupation by industry group (a cross-tabulation of, for example, accountants and auditors in agriculture, forestry, and fisheries).

These sorts of data are available also for the whole United States and for the State of Colorado. The national data show more industry and occupational detail than do the local data, and also percentage changes from 1950 to 1960.

[20/] *Ibid*.

Also shown are cross-tabulated tables showing employment in each of the 211 standard metropolitan statistical areas over 250,000 population (including Denver) in each of several industry groups for 1950 and 1960. The SMSA employment (excluding the two standard consolidated areas of New York-Northeastern New Jersey and Chicago-Northwest Indiana) is summed to show a national total for the 211 SMSA's for 1960. No total is shown for 1950.

Denver Area Skill Survey

Occupational data are available from an area skill survey that was conducted for the Denver Standard Metropolitan Area during the summer of 1958. Most of the results of the survey were tabulated in an occupational inventory showing how many people were employed in each occupation, how many employees in each occupation would be needed in 1960 and 1963 (according to the opinions of the individual employers), which occupations were entry-type jobs, which were shortage-type jobs, and the minimum educational requirements for employment in each occupation. In addition, a tabulation showing the distribution of employment by occupational group and the distribution of workers within industries was released. Unfortunately, those persons not covered by the Colorado Unemployment Compensation Program were not included in the scope of the survey. These amounted to roughly 20 per cent of the labor force. The exclusion of self-employed persons and workers in establishments with less than four employees biased the sample relative to total employment, since large portions of certain industry groups -- for example, services -- were excluded.

Occupational Wage Surveys

An occupational wage survey of the more important occupations has been conducted on a sample basis by the U. S. Bureau of Labor Statistics in the Denver area every year, except one, since 1949. Its primary purpose is to provide information on occupational earnings. These data have been compared with data from other local areas by the Bureau of Labor Statistics.[21]

Occupational employment estimates in the local survey represent the total in all establishments within the scope of the study, which varies from year to year. The scope included 48 per cent of all the establishments, except government, in the SMA with eight or more workers in 1949; and all of the establishments, except government, in the SMSA with 50 or more workers in 1964. According to BLS, the workers-within-the-scope-of-study estimates shown provide a reasonably accurate description of the size and composition of the labor force included in the survey.[22] However, the survey does not include all of the workers in the local economy, nor all of the workers in any one industry. The estimates show the number of workers in the scope of the study, and bear no close relationship to the size of employment within an industry or the size of total employment in the local economy. Furthermore, the scope of the study relative to the size of total employment appears to change from year to year. Hence, the estimates of employment, by occupation or by occupation-by-industry, do not appear to reflect a consistent enough relationship between size of sample and size of universe from year to year to use as a measure of trend or as a comparison with employment data from other sources.

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[21] See Wages and Related Benefits, U. S. Department of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office.

Other Data

Other data are available for specific occupations. Unpublished data of employment by occupation by industry in more industry detail than published in the 1960 Census of Population for the Denver Metropolitan Statistical Area are available from the U. S. Bureau of the Census. Unpublished occupational detail is available for Boulder County for 1960. However, no unpublished detailed information is available for any area from the 1950 Census, because "several years ago," *in order to economize on space,* the Census Bureau destroyed its IBM cards on the 1950 Census, and letters and telephone calls to approximately 25 persons who might have obtained these data before they were destroyed failed to be fruitful.

The Monthly Report on the Labor Force provides on a national basis monthly occupational employment figures for several occupations. It is possible that unpublished detail for the Denver SMSA might be available.

The Civil Service Commission has records which show employment by occupation or occupational group in the classified civil service.

Federal regulatory agencies have data on a national basis which show the occupational structure in the regulated industries (airlines, interstate motor carriers, pipelines, railroads, and tele-communications). It is possible that these data might be available in greater geographical detail than the United States.

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[22] Occupational Wage Survey, U. S. Department of Labor, Bureau of Labor Statistics, Washington: U. S. Government Printing Office (1964), p. 3.

Federal agencies have estimates of national employment of college teachers, elementary and secondary school teachers, engineers, librarians, policemen, scientists, and technicians. They may also have geographical detail on worksheets.

Some local and state licensure agencies can provide the size of occupational employment in those occupations which require a license.

Estimates of size of employment in certain of the professions can be developed from the membership records of professional societies.

APPENDIX II

A METHOD FOR FORECASTING REGIONAL EMPLOYMENT BY OCCUPATION

A METHOD FOR FORECASTING REGIONAL EMPLOYMENT BY OCCUPATION

I

INTRODUCTION

A great deal of effort has been devoted in recent years to projections of occupational-employment levels within relatively self-contained regions. One assumption common to many of the methods employed is that of proportionality among all the variables used in the analysis. For example, some of these techniques start by projecting population by age and sex to 1970 and 1975. From specific assumptions of participation rates and unemployment, the total employed labor force is determined. Finally, this estimate of the labor force is distributed by occupations and industries according to the 1960 distributions in the region under study. The proportionality assumptions incorporated in these methods imply a constant industry-occupation mix which limits their value as forecasting tools.

Another technique is the "land-base" or "location coefficient" approach. The crucial assumption underlying this approach is again one of proportionality. This method assumes that various ratios of employment to population in the nation apply to the region under study. It allows for none of the factors which are unique to a regional economy and which will thus influence its growth pattern. The many difficulties inherent in this type of analysis are pointed out by Professor Charles Leven in his analysis of regional accounting methods.1/

1/Charles L. Leven, "Regional Income and Product Accounts: Construction and Applications," in Design of Regional Accounts, Werner Hochwald (ed.), Baltimore: The Johns Hopkins Press (1961); Charles L. Leven, Theory and Method of Income and Product Accounts for Metropolitan Areas, Including the Elgin-Dundee Area as a Case Study, Ann Arbor: University Microfilms (1958), Thesis, Northwestern University.

Some authors consider still another approach as comprising a distinct method -- namely, the so-called "historical method."[2] This method can best be described as a more or less intuitive approach based on a vast accumulation of the historic, social, economic, and political developments of the region under study. Then, having obtained an intuitive "feel" for the region, the investigator proceeds to make judgments as to the most likely future development to be expected on the basis of past trends.

The historical approach should not be considered as a distinct method; rather, it should be the foundation upon which all forecasting methods are based. However, a purely verbal historical approach will not possess the extension nor the penetration afforded by a rigorous analytical framework properly integrated with a broad knowledge of the region's existing, as well as historical, socio-economic trends. Therefore, the method presented in this paper will provide a rigorous analytical framework for the use of extensive historical and time series data. Further, the method will eliminate the standard proportional assumptions underlying many forecasting techniques and will introduce some of the nonlinear trends known to exist in any real economy. The framework is designed, however, to allow for the unpredictable and unstable features found in any economy. The technique permits the investigator to separate the stable elements of an economy from the unstable, and to determine their interaction in the process of forecasting industry-occupational trends.

A fundamental assumption upon which this method rests is that there is a stable relationship between aggregate demand and aggregate employment.[3] It is further assumed that there is a stable relationship between aggregate output and employment for each industry included in the forecast. The reasonableness of this assumption is demonstrated later in this paper. It is expected, of course, that there will be variations in output, and that judgments will be required when projecting the unstable sectors of the regional economy. The model is sufficiently flexible, however, to allow for such judgments.

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[2] See, for example, Manpower Skill Requirements and Training Needs, Philadelphia Labor Market Area (Pennsylvania Portion), November 1962, Commonwealth of Pennsylvania, Department of Labor and Industry, Bureau of Employment Security, Research and Statistics Division; Lane County Labor Skill Survey, Oregon State Employment Service, a division of the Department of Employment, in cooperation with the United States Department of Labor.

[3] This is the familiar Keynesian principle. See, for example, Gardner Ackley, Macroeconomic Theory, New York: The Macmillan Company (1961), or Dudley Dillard, The Economics of John Maynard Keynes, New York: Prentice-Hall (1948).

II

THE METHOD

The method considered here identifies long-run industry-occupational relationships, stable short-run trends, and unstable short-run factors which cause employment levels to deviate unpredictably from long-run occupational trends. A series of decennial industry-occupation matrices will be constructed which will be examined for both long-run structural stability as well as structural changes in the industry-occupational complex of the region under study.[4] Employment-output functions have been developed from time series data, and these are used to account for the stable short-term features of each industry's prevailing productive relationships.[5] In other words, short-run production functions are derived for all industries included in the study.

The third phase explicitly accounts for the unstable features in the regional economy which are primarily manifested by variability in each industry's total demand. Since changes in output over time reflect adjustments to changes in demand, relations of output as a function of time are derived. These output-time relations form the analytical basis for output predictions. It is at this stage that judgments with respect to the probable growth paths of each industry are incorporated in the model.

Finally, the three phases are integrated so as to form a complete model; that is, output values as a function of time for all industries are used in conjunction with the industry production functions to project future levels of industry employment which in turn are coupled with the industry-occupational matrices to obtain the final occupational-employment levels.

The detailed development of the method will be discussed in the following order: (1) the industry-occupation matrix, (2) the industry-production functions, (3) the output-time relations, and (4) the integration of these phases into the complete model. The next section contains a detailed numerical application of this method to the Denver SMSA for selected industries and occupations.

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[4] Starting with 1960, matrices will be constructed for ten year periods possibly extending as far back as 1910.

[5] Short-term here implies a period of ten years or less.

The Industry-Occupation Matrix

Consider m occupations and n industries in the region under study. Denote the industries by I_j ($j = 1, 2, \ldots, n$), and the occupations by O_i ($i = 1, 2, \ldots, m$). There are no restrictions on the dimensions of the matrix, i.e. ($m > n$, $m < n$, or $m = n$). Let E_j^t denote the industry's total employment during time period t.[6]

Suppose further that employment levels over period t for occupations, O_i, can be determined for each of the industries. Denote these industry-occupation employment levels by e_{ij}^t -- that is, the level of employment of occupation i in industry j over time period t. Now form a matrix of the e_{ij}^t's. Call this matrix the industry-occupation structural matrix at time t and denote it as

$$S^t = \left[e_{ij}^t \right]_{m,n}$$

From this derive a coefficient matrix, C^t, defined as

$$(1) \qquad C^t = \left[a_{ij}^t \right]_{m,n} \quad \text{where} \quad a_{ij}^t = \frac{e_{ij}^t}{E_j^t}$$

The a_{ij}^t of the coefficient matrix is interpreted as giving the percentage of industry j's total employment in the i^{th} occupation at time t.[7] The column vector, $A_j = \left[a_{1j}, a_{2j}, \ldots a_{mj} \right]^T$, gives the total percentage allocation of industry j's total employment among all occupations.[8]

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[6] Any standard measure of employment can be used, e.g. man-years or man-hours.

[7] There is a similarity between the structural matrices used in this model and those used in interindustry (input-output) analysis and intersectoral flows analysis. See, for example, Hollis B. Chenery and Paul G. Clark, Interindustry Economics, New York: John Wiley (1959); and W. Lee Hansen and Charles M. Tiebout, "An Intersectoral Flows Analysis of the California Economy," The Review of Economics and Statistics, Vol. XLV (November 1963), No. 4.

[8] Some of the a_{ij}'s may be zero if the particular occupations are not included in industry j.

We can now define the coefficient matrix as either inclusive or selective. If

$$E_j^t = \sum_{i=1}^{m} e_{ij}^t, \; j = 1, 2, \ldots, n,$$

the matrix C^t is inclusive; that is, all occupations in each industry are included in the matrix classification. In the inclusive matrix, total industry employment is the sum of employment in the individual occupations.

If the sum of employment in the individual occupations does not equal that industry's total employment, the coefficient matrix is selective. With this distinction a complete occupational breakdown is not necessary. In such cases each industry's total employment level must be determined from sources other than the structural matrix.

Alternatively, an inclusive matrix can be derived from a selective matrix by defining a residual occupational group which includes all those occupations not explicitly classified elsewhere in the selective breakdown. This residual occupation is formed by taking the difference between each industry's total employment, E_j^t, and the sum of all occupational employment levels explicitly listed under that industry. If we let the m^{th} occupation be the residual occupational group, then

$$e_{mj}^t = E_j^t - \sum_{i=1}^{m-1} e_{ij}^t, \; j = 1, \ldots, n.$$

The advantages of defining a residual occupational group in the construction of both the structural and the coefficient matrices, even for an analysis requiring only selected occupations, will be demonstrated in the numerical section of this paper. A number of internal checks made possible by this technique can then be utilized in the empirical construction of the matrices

The coefficient matrices show the inter-occupational industry employment structure of the region under investigation. These matrices reflect the stable yet changing, long-run economic forces which affect the occupational structure of the region's industrial complex.[9] Some of the facets of the industrial growth and development of the region which will be reflected in the coefficient matrices are changing industrial productive techniques, the transformation of old and entry of new firms into new and broader fields of activity, and the effects of exogenous forces on employment relationships in the various industries in the region. The coefficients will also be affected by economies of scale associated with larger plant capacity, and the increasing application of automated production control. They will also be affected by increasing efficiency in transportation and communications which will influence inventory policy as well as the coefficients for the transportation industry itself.

Other employment characteristics embodied in the coefficient matrices include those reflecting the gradual transformation of existing industries and the emergence of new industries into new fields such as the recent growth trends in air transportation, air freight, electronic computers, new alloys and plastics. The results of trade union activity, such as increasing wage demands, shorter hours, and job reclassification are also implicitly incorporated in the coefficient matrices.

The above examples illustrate some of the many underlying forces which are interrelated and summarized by the corresponding elements of coefficient matrices constructed over successive time periods. That is, the coefficients in the matrices show the net effect of many forces on the industry-employment structure of the industries and occupations included in the study.

The functional relationship existing between the coefficient matrices over successive time periods can now be formulated explicitly. Consider a time series of matrices giving the a_{ij}^{t}'s for each i and j over k successive time periods; that is,

$$\left[a_{ij}^{1}\right]_{m,n}, \left[a_{ij}^{2}\right]_{m,n}, \ldots, \left[a_{ij}^{k}\right]_{m,n}.$$

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[9] It is assumed that the associated occupational structure is not vulnerable to radical change deriving from any foreseeable entry (exit) of new (old) firms in the region. The stable relationships appear as percentages in the coefficient matrices; they are not necessarily reflected in the structural matrices. The structural matrices represent levels of industry employment rather than the interindustry-occupational structure which is reflected in the coefficient matrices.

Now fit an appropriate curve to the corresponding a_{ij}'s over the k time periods to obtain a matrix all of whose elements are functions of time. Let U (t) denote this matrix. That is,

$$(2) \qquad U\,(t) = \begin{bmatrix} f_{ij}(t) \end{bmatrix}_{m,n}$$

where $f_{ij}(t)$ is the curve fitting the corresponding a^t_{ij}'s, t = 1, . . ., k.[10/]

Assume for the moment that total employment levels in all n industries are known at some time period t. Form an n x 1 column vector of these employment levels and denote it as

$$(3) \qquad V^t = \begin{bmatrix} E^t_j \end{bmatrix} .$$

Express the m individual occupational employment levels at time period t by the m x 1 column vector

$$(4) \qquad W^t = \begin{bmatrix} R^t_i \end{bmatrix} ,$$

then W^t is given by the equation

$$(5) \qquad W^t = U(t) \cdot V^t ,$$

or in expanded form,

$$R_1 = f_{11}(t)\ E^t_1 + f_{12}(t)\ E^t_2 + \ldots + f_{1n}(t)\ E^t_n$$

$$R_2 = f_{21}(t)\ E^t_1 + f_{22}(t)\ E^t_2 + \ldots + f_{2n}(t)\ E^t_n$$

$$\cdot \quad \cdot \quad \cdot$$

$$R_m = f_{m1}(t)\ E^t_1 + f_{m2}(t)\ E^t_2 + \ldots + f_{mn}(t)\ E^t_n$$

[10/] A series of functions fitted by the method of least squares are compared by various measures of "goodness of fit" to obtain the "best" curve.

If the total industrial-employment levels (V^t) for some future period can be determined, the future occupational-employment levels can be obtained by direct matrix multiplication with the projected coefficient matrix U(t). It must be emphasized that the industry-employment levels must be determined independently of the matrices (structural and coefficient). The independent determination of individual industry-employment levels involves the second phase of the method.

The Industry Production Function

The relative employment levels of the component industries within a broad industrial classification are reflected in each industry's column in the coefficient matrix, but the aggregated level of production of the heterogeneous industry group must somehow be related to total industry employment. Thus, production functions are derived for each industrial classification. These functions demonstrate the stable short-run trends in employment-output relationships in each industrial classification.

The employment-output functions are used to evaluate predictable, short-run trends which deviate significantly from long-run, structural changes, and which would be obscured if viewed solely from a long-run perspective. Hence, it is necessary to examine time series data of industry-employment versus output over a period of years sufficiently long to show both the long-run trends and short-run variations around these trends. Production functions are then approximated over the most recent stable short-run trends prior to the base year for each industry sector in the study. Changes in scale of plant, gradual transformation to automated techniques, and similar changes in the individual industries within an industrial group would be reflected in a stable short-run trend. Sweeping changes simultaneously occurring in several important industries within a given sector, however, will be reflected by a discontinuity in the industry production function.

The present method does not analytically account for shifts in industry production functions over the prediction period since such shifts usually occur over longer time periods. However, if there is reason to anticipate shifts in a production function at the time a forecast is made, such shifts can be incorporated into the method on the basis of judgments from persons familiar with the particular industries involved.

Now consider the possible forms which the industry production functions can assume. For each industrial sector, I_j $(j = 1, 2, \ldots, n)$ it is necessary to obtain output and employment data for deriving the functional relationships between employment and output. Designate these functions as:

$$(6) \qquad E_j = g_j(X_j),\ j = 1, 2, \ldots, n,$$

which are derived from the ordered pairs, (X_j^t, E_j^t), where t varies over all the time periods included in the short-run as defined above.

Equations (6) are actually independent of the time variable, although implicitly they depend on the ordered pairs, (X_j^t, E_j^t), corresponding to a succession of time periods. In later sections it is shown how these implicit time relationships are utilized in the fully integrated model.

Output can, of course, be expressed in a number of different ways. Here the term "output" is used as a general designation for all possible variables which are significantly correlated with short-run changes in the level of employment. The purpose of incorporating a measure of output into the method is to introduce an economic variable, closely related to effective final demand, which ultimately determines final levels of production. Final demand will be the variable most suitable for predictive purposes due to its independence from the technical relationships in the various industries. If this were not the case, it would be sufficient to predict on the basis of employment alone. A time series of employment levels, however, reflects many changes other than changes in final demand, such as changes in factor proportions and changes in other variables not explicitly discussed in this paper.

For most private sectors, dollar sales expressed in real terms would be the first choice of a measure of output.[11] In public sectors total wages and salaries is the preferable as well as the most commonly used measure of output. Other possible measures of output are value added, gross margins (for trade sectors) and total earned income.[12]

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[11] No attempt was made to derive separate industrial price indices in the numerical implementation of the model since this would have taken us beyond the scope of this project. See the 1954 Supplement to the Survey of Current Business, National Income, pp. 153-8.

[12] In this section where the method is implemented, the only data available for private sectors over a sufficient number of years was total wages and salaries. In some of the manufacturing sectors, total value added was used. Admittedly these selections are not ideal; however, they were the only approximations available.

Employment can be measured in at least two ways: First, the average number of employees during some time period can be used. The major deficiency of this measure is that it applies to an employee independently of the duration of his employment in an industry within the given time period. In other words, a temporary employee working two weeks out of a year counts the same as a full-time employee. Further, this method can lead to multiple counting of employees in the same or different industries for those workers moving from one firm to another within the time period.

A more accurate measure of industry employment levels is that of total man-hours during some time period. This measure avoids the difficulties mentioned above. It is not available, however, in the detail required by this method. Further, this measure can easily be converted to the first.

Suppose now that appropriate measures of output and employment have been chosen for all industries considered in the study. It is important to remember that the same measure need not apply to all industries alike. Then suppose a sufficient number of successive ordered pairs, (X^t, E_j^t), are available over a sufficient number of time periods so that we can clearly distinguish employment-output trends. Then the employment-output functions represented by equation (6) are determined through the use of least square fits to selected functional forms (see footnote 10).

Output Functions

Consider now the successive measures of output used in the derivation of the employment-output functions in conjunction with the time variable to obtain ordered pairs relating industry output levels to time; that is, the succession of ordered pairs,

$$(t, X_j^t), \quad j = 1, 2, \ldots, n ,$$

where t ranges over the same short-run period considered in the development of the production functions.

As in the preceding section, functions of output versus time are derived. These functions, however, will not be used for the purpose of direct prediction through extrapolation or interpolation. Instead, future trends of industry output, which are predicted on the basis of these output functions, will be used as reference data upon which judgments can be based as to probable expansion paths of each industry.

Then assume that from the set of ordered pairs, (t, X_j^t), the following output functions are derived:

$$(7) \qquad X_j = h_j(t), \quad j = 1, 2, \ldots, n$$

for all n industries.

First consider the output functions for those industries which show a high degree of stability -- that is, those industries which tend to maintain a relatively constant rate of growth and tend to be little affected in the short-run by most changes in the economic structure of the region. These industries are in most cases export industries having wide, extra-regional markets. Hence, it would be worthwhile to separate by some criterion the industries which would be considered export industries,[13] from those having predominantly local sales outlets.

A typical output function for such stable industries will look similar to the one shown in Figure 1.

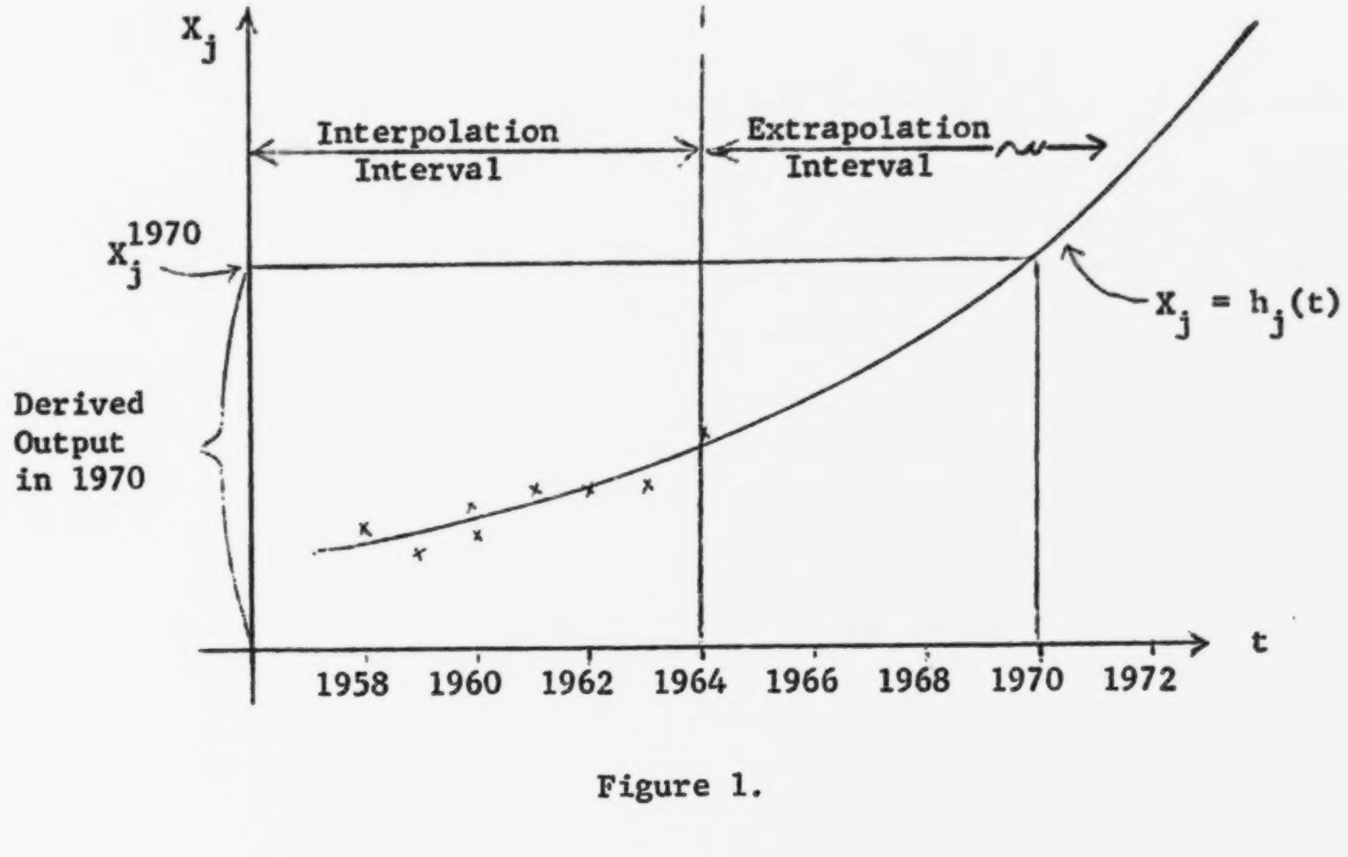

Figure 1.

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[13] This classification is made in the numerical section of the paper.

For the stable industries, it will be sufficient to predict future output levels by direct extrapolation using the derived functional form, $X_j = h_j(t)$.

Now examine the industries that are known to respond significantly to exogenous changes which in turn are subject to highly unpredictable causes. An example of this type of industry would be one depending on government contracts which can be cancelled or awarded for reasons completely beyond the control of the local region. Another example would be a private industry which begins to expand in the region through autonomous investment planning.

A strict extrapolation based on such an industry's output functions would be highly unreliable. Therefore, it is necessary to first classify each industry according to its most probable future level of output relative to its past short-run production activity as follows: (1) an expanding industry, (2) a level industry, and (3) a declining industry. These classifications will be made on the basis of a detailed knowledge of both economic and extra-economic factors affecting each industry under consideration. That is, by means of interviews with individuals having considerable personal experience with the industry's activities, or in general by means of a thorough analysis of the historical as well as current socio-political and economic factors affecting the industry in its local, regional, and national spheres of activity, a decision will be made about how to classify each industry according to its most probable future level of output. These industries will then fall into one of the following categories: (1) those expanding, more rapidly than their $h_j(t)$ would indicate; (2) those expanding according to $h_j(t)$, or (3) those expanding less rapidly than $h_j(t)$. Thus, the output functions are used as data upon which future levels of output can be referenced.

As an example, consider an industry which has been an expanding industry during a base period, say 1958-1963. Suppose further that a classification has been made through the procedure outlined above and that the industry falls in category (1). Now suppose that from an investigation of the industry under consideration it is anticipated that its activities will expand by 10 per cent more per year for the next ten years than the rate of growth during the base period.[14] Hence, the slope of this accelerated expansion path will increase by 10 per cent more than the average slope determined by the industry's $h_j(t)$

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[14] Base period here refers to the stable short-run period over which the $h_j(t)$'s are approximated.

over the same ten year period. Thus, the projected level of output for 1970 can be determined analytically on the basis of this judgment as Figure 2 demonstrates graphically.

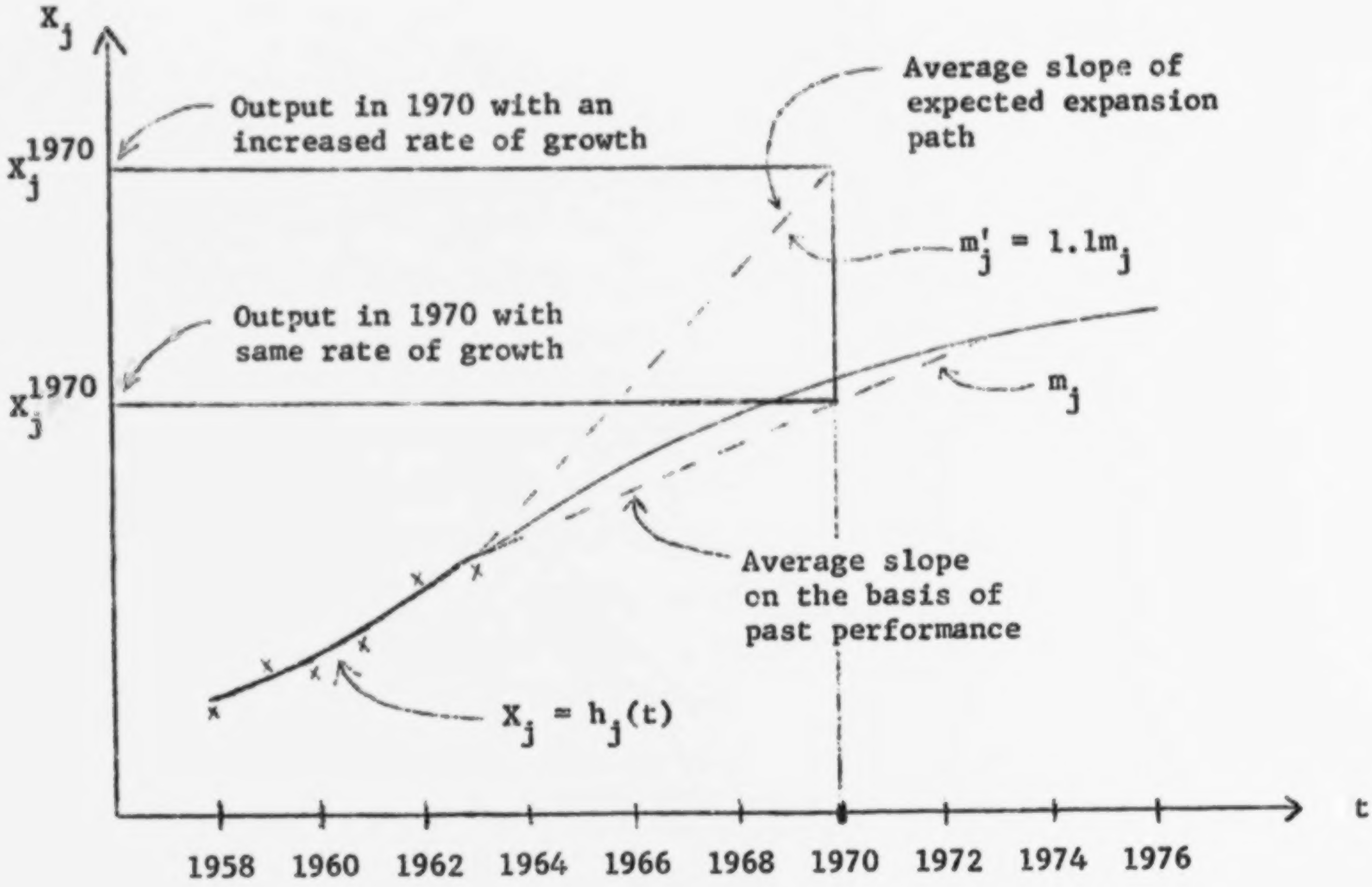

Figure 2.

Many similar determinations can be made on the basis of other judgments concerning the industry's expected rate of growth or future expansion plans. The point to be emphasized is that the extrapolated $h_j(t)$ forms a reference or datum upon which the investigator can base his judgments about the most probable future level of output.

It is possible that examination of the various industries considered in the study will call for more than one future output level for several of the industries. In fact, it is possible to assign probabilities to alternative predictions of future output levels for particular industries. For example, if a reasonably large number of interviews are conducted the predictions derived from these interviews can be categorized into possible outcomes, and the frequency of each outcome can be used to estimate the probability assigmed to that outcome. Thus, it is conceivable that more than one predicted future output level will have to be considered for several industries.

Also, for certain industries that are considered to be of crucial importance to the region, it will be helpful to determine an upper as well as a lower bound on future output and use both of these to compute a range of industry-occupational employment levels.[15]

Since more than one feasible expansion path can be established for each of these unstable industries, it is necessary to consider all possible combinations of expansion paths to determine separate industry-occupational employment projections corresponding to each of these combinations. The most probable expansion path is used for most industries in the final employment projections.

For those subsidiary industries which are primarily dependent on the levels of output of various export industries, endogenous relationships can be derived between their output levels and the aggregate of several or all of the export industrial output levels. These subsidiary-export industry relationships are clearly revealed in inter-industry input-output analysis. Of course, induced income effects as well as direct effects are involved in this type of analysis, and income as well as employment multipliers can be derived.[16] This type of analysis is primarily applicable to an inclusive rather than a selective system.

The Complete Model

Suppose we have obtained a first combination of future output levels for all n industries at some time t. Denote these predicted output levels by the functions,

$$(8) \qquad X_j = p_j(t), \quad j = 1, 2, \ldots, n.$$

For the stable industries, as defined above,

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[15] It is expected that a full and detailed application of the procedures for making judgments as to future industry-output levels will be included in the final OMAT report.

[16] Frederick T. Moore and James W. Petersen, "Regional Analysis: An Interindustry Model of Utah," The Review of Economics and Statistics, Vol. 37, No. 4, November 1955, p. 368. Also the authors are currently engaged in extending this type of analysis.

$$p_j(t) = h_j(t),$$

and for the unstable industries the $p_j(t)$'s denote probable expansion paths. Thus $p_j(t)$, $j = 1, 2, \ldots, n$, denotes a feasible combination of future output levels.

With these future levels of output, the industry production functions, $g_j(X_j)$, give

$$(9) \qquad E_j^t = g_j(X_j^t) = g_j \left[p_j(t) \right] \quad , j = 1, 2, \ldots, n$$

where the superscript t on the variables X_j and E_j, are used to denote the predicted values of these variables at the future time period t.

Referring to equation (5), the occupational employment levels are, R_i, $i = 1, 2, \ldots, m$, according to the particular combination of p_j's chosen. That is,

$$(10) \qquad W^t = U(t) \cdot V^t,$$

or in expanded form,

$$R_1 = f_{11}(t) \cdot g_1 \left[p_1(t) \right] + f_{12}(t) \cdot g_2 \left[p_2(t) \right] + \ldots + f_{1n}(t) \cdot g_n \left[p_n(t) \right]$$

$$R_2 = f_{21}(t) \cdot g_1 \left[p_1(t) \right] + f_{22}(t) \cdot g_2 \left[p_2(t) \right] + \ldots + f_{2n}(t) \cdot g_n \left[p_n(t) \right]$$

$$\cdots$$

$$R_m = f_{m1}(t) \cdot g_1 \left[p_1(t) \right] + f_{m2}(t) \cdot g_2 \left[p_2(t) \right] + \ldots + f_{mn}(t) \cdot g_n \left[p_n(t) \right] ,$$

where $R_1, R_2, \ldots, R_m$ are the required occupational employment levels expressed in the chosen measure of employment. Equation (10) is the complete mathematical formulation of the model; however, there is a further significant process implicit in this model which should be considered before concluding this section.

In general, a particular occupation is common to many distinct industries as will be seen in the coefficient matrices in the numerical section of this paper. The final occupational employment level is determined by the combined effect of the various rates of growth or decline of the separate industries. For example, consider the simple case of one occupation which is entirely allocated between only two industries, where one industry is expanding in both output and employment and the other industry is declining. Assuming relatively uniform conditions such as comparable wage rates and travel distances, there will be a shift of workers from the declining industry into the expanding industry. The net effect of this transition on the total occupational employment level will be an increase or a decrease depending on the rates of change and relative capacities of the two industries.

In general, given any combination of probable expansion paths for all n industries considered in the study, the final m occupational employment levels given by the R_i's, depends on an m by n occupational-industry employment mix. For all m occupations there are employment interchanges between all industries that include those respective occupations but which are not explicitly evaluated in the determination of final occupational employment levels. Nevertheless, the net result of these interactions are accounted for in the final determination of the R_i's of equation (10). That is, the occupation mix between all m occupations and n industries is accounted for simultaneously in the operation of this technique.

We have thus far accounted for the long-run secular trends in the inter-industry-occupational structure of the region under study by use of industry-occupation coefficient matrices considered as functions of time. We have accounted for local, individual industry characteristics which show stability in the short-run through the construction of industry production functions. We have also outlined a method for determining the various output levels of the many possible expansion paths open to those industries which are governed by forces exogenous to the region, or those industries which are just not amenable to analytic forecasting techniques, and we have indicated how various occupational employment levels can be determined, depending upon the various choices of combinations of industry-expansion paths. Finally, we showed how occupation-mix phenomena are accounted for in the final operation of the model.

III

STATISTICAL IMPLEMENTATION OF THE MODEL

In this section a numerical example of the model as applied to the Denver Standard Metropolitan Statistical Area is given. The SMSA consists of five counties: Adams, Arapahoe, Boulder, Denver and Jefferson. The application follows the order used in the development of the theory, namely: (1) construction of the coefficient matrices, (2) derivation of the industry production functions, (3) development of industry-output functions (industry expansion paths), and (4) integration of parts (1) through (3) into the final occupational-employment forecasts.

This application is limited to a selective industry-occupational breakdown. It includes ten prominent industries in the Denver area and twenty occupations carefully chosen for their occupational training potentials. It is hoped that before the final report is completed an inclusive industry-occupation study will be made so that a complete forecast for the Denver SMSA will be available.

The Coefficient Matrices

Three inclusive matrices have been constructed, corresponding to the years 1940, 1950 and 1960. The point of departure in the development of these matrices was the data contained in the 1960 U. S. Census of Population for the Denver SMSA.[17/] These data were organized in the form of a structural matrix for male workers and female workers separately. Coefficient matrices were derived directly from the given census, occupational-industry breakdowns for (1) males, (2) females, and (3) males and females combined. In all three cases, if we were to use these matrices we would be forced to accept the industries and occupations listed in the census matrix. In the male-female aggregation, many of the occupations listed are not comparable. For example, secretaries are specifically listed in the female matrix, but in the male matrix they are lumped into a residual category, "other clerical and kindred workers." Further, the entire class of engineering occupations in the female matrix are lumped into "other professional, technical, and kindred workers."

[17/] United States Census of Population, 1960, Colorado, Detailed Characteristics, U. S. Department of Commerce, Bureau of the Census.

These differences in occupational classification severely limited the choice of occupations. Therefore, it was necessary to devise a method by which structural matrices could be derived for any desired set of occupations for male, female, or combined workers. In fact, such a technique was necessary for the construction of the 1950 and 1940 structural matrices since the census data for these years was not compiled into a detailed occupational-industry matrix.

Also, the industry classifications used in the 1960 census occupational-industry matrices are in some cases too broad for our purposes. For example, a vital and growing industry in the Denver SMSA is the air transportation industry which in the census is entered in a residual industry called "all other transportation."[18/] Hence, a technique is needed which not only will enable us to derive specific occupational employment totals in the various industries, but will also enable us to disaggregate the broad industrial classifications used in the census into industries which are more suitable for this study.

In the census data, total employment figures are listed for a large number of detailed occupations; further all of these occupations are categorized into major occupational classes such as professional, technical and kindred workers; clerical and kindred workers; operatives and kindred workers; service workers including private households; and so on. Employment totals are given for each of these major occupational classes and these totals are broken down by industry. For example, the total number of male and female designers and draftsmen for 1960 is 2,232. Further, designers and draftsmen fall into the broad occupational classification -- professional, technical and kindred -- for which a total of 53,270 employees is listed. Of this total, the fabricated metal industry employed 4,249, the wholesale trade industry employed 607, and so on.

With this type of breakdown for all industries and occupations we allocate the total number of employees of each detailed occupation to each industry. First, for every industry, we compute the ratio of the number of employees in each major occupational group in that industry to the total number of employees in the same major occupational group. For example, using the above figures,

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[18/] In the final report, air transportation and several other key Denver industries will be specifically incorporated in the inclusive matrices.

the ratio of designers and draftsmen in the professional, technical and kindred major group for the fabricated metal industry is

$$\frac{4,249}{53,270} = 0.07976 \ .$$

These ratios are used to allocate the detailed occupational totals to each of the industries included in the analysis. In this example of 2,232 designers and draftsmen, (2,232) x (.07976) = 178, which is the estimated total of male and female draftsmen and designers employed in the fabricating metal industry in 1960.

This technique was used to build inclusive structural matrices for male, female, and male-female combined for the years 1940, 1950 and 1960. From these, coefficient matrices were constructed by dividing each column by the industry-column totals.[19]

At this point, the crucial question is: How accurate is this allocating technique? The fundamental assumption in this data reconciliation process is that all minor occupational employment levels are distributed among all industries in the same proportions as total employment in the major occupation classification. That is, the minor occupations are assumed to be homogeneous within each major occupational group. While this assumption might not be realized in all cases, we feel that the matrices derived by this process are sufficiently accurate to reveal the required structural trends. However, if one were to use the derived structural matrices in an element-by-element time series projection for direct occupational-industry forecasts, this would be a very doubtful procedure.

It would be a mistake to consider these derived matrices, both structural and coefficient, as representing the true industry-occupational employment structure of the region. Rather, the derived matrices represent the trend in the changing structure of the region. The fact that they are not totally comparable to what would be "true" structural and coefficient matrices will not significantly obscure the structural trends. Nevertheless, since the projected coefficient matrix will be used as if it represented the actual future industry-occupational structure, it will be advantageous to adjust the derived matrices, which only reflect the structural trend, so that they will more nearly approximate the actual allocation of occupational employment by industry.

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[19] Similar matrices are currently being constructed for 1930 and 1920. At the time of writing only the 1940, 1950 and 1960 matrices were completed. However, it was felt these are sufficient for the exploratory forecasts since they will in most cases show post-war structural trends.

This adjustment process is achieved by the following transformation: The recorded elements of the 1960 structural matrix found in the census data are divided by the corresponding elements in the derived 1960 matrix. That is, if e_{ij} denotes an arbitrary element from the given census matrix and e'_{ij} represents the corresponding element in the derived 1960 matrix, the adjustment coefficient, denoted by k_{ij}, is given by the quotient,

$$k_{ij} = \frac{e_{ij}}{e'_{ij}} ; \quad i = 1, 2, \ldots, m; \quad j = 1, 2, \ldots, n.$$

Denote this collection of scale factors by the matrix,

$$K = \left[k_{ij} \right]_{m,n}.$$

The matrix K is used to adjust the projected 1970 and 1975 derived coefficient matrices by making an element-by-element multiplication. That is, the final coefficient matrix will be

$$C^{t'} = \left[k_{ij} f_{ij}(t') \right]$$

where t' will be the years 1970 and 1975 respectively for this application. Thus, this adjusted future coefficient matrix should yield a more accurate numerical occupational-employment forecast than would be the case if the "trend" coefficient matrices were used exclusively. The matrix of adjustment coefficients is given in Table 5.

With the completion of the 1930 and 1920 matrices, it will be possible to make a test forecast to determine both the accuracy of projection as well as the stability of the coefficient matrices. This will be done by using the derived matrices up to and including 1950 to project the 1960 matrix (which is known). It will then be possible to compare the forecasts with the realized values and examine the margin of error. In fact, this general idea will be applied to the entire model, and exploratory occupational-employment forecasts will be made for 1960 and 1965.

To maintain computational accuracy when deriving the matrices, it is best to build inclusive matrices using residual occupational and industry categories as discussed earlier. For each major occupational group, we form a residual category which includes all those detailed occupations in that major group which are not otherwise specifically listed. Similarly, residual industries are used for each major industrial category (i.e. manufacturing, transportation, services, etc.). An example of a residual occupation is "other clerical and kindred workers" in the major group "clerical and kindred workers." In the manufacturing industries, "other durable goods" is an example of a residual industry.

With these residual categories built into the matrices, we are able to devise many computational checks to keep a running account of the accuracy of the derived structural and coefficient matrices. For example, the sums of all the derived occupational figures in each industry should equal the figures for each major occupational group broken down by industry as recorded in the census. Also, the sums of the derived occupational figures over all industries should equal the total occupational employment figures recorded in the census.

Besides the internal reconciliation difficulties, there are also aggregation and classification difficulties with the data. There have been many changes in the methods of aggregating job occupations from one census period to the next. For example, the 1950 census includes as a job classification "guards, watchmen and porters." In the 1940 census, the corresponding classification is "guards, watchmen and doorkeepers." Another difficulty arises from changes in major occupational groupings between the various census periods. This, of course, makes the structural comparability for some occupations in the derived matrices very dubious from one census period to the next. For example, in 1940 a major occupational classification is "clerical, sales and kindred workers." In 1950, the same group is divided into two separate categories -- "sales workers" and "clerical and kindred workers," thus introducing a distinct new major occupational group.

Geographical difficulties are also encountered in the construction of these matrices. The census data from 1940 and earlier include only Denver county. In 1950, the Denver SMA was defined as Adams, Arapahoe, Denver and Jefferson counties. Finally, in 1960, the census data include the entire SMSA which incorporated Boulder county into the SMA. In the selective matrices, these geographical difficulties are not significant since the industries chosen are predominantly covered by the areas used in each of the census periods. In the final inclusive system, it will be necessary to [illegible] geographical differences. This can be done simply by adding in the necessary employment figures for the counties or census tracts of the missing areas to make the entire set of matrices comparable.

Despite these internal as well as external difficulties, when the derived coefficient matrices for 1960 are compared with the coefficient matrices derived from the structural matrices contained in the 1960 census, corresponding elements are found to be in the majority of cases of the same order of magnitude thus substantiating (at least for 1960) the feasibility of this allocating technique.[20]

The selective coefficient matrices used in this application are given in Tables 1-3. All of the coefficients in each of these matrices have been multiplied by 1,000 to render the numbers more readable. Using these matrices, functions of time fitting all of the corresponding elements in each of the three matrices were derived. Linear, exponential, and geometric least squares fits were applied to each set of three ordered pairs for all m x n locations in the matrix. The functions were then compared on the basis of their correlation coefficients and standard errors.

The correlation coefficients and the standard errors of estimate of the functions finally chosen are given in Table 4. The functions themselves are listed on the pages following Table 4. The matrix of functions was then evaluated for 1970 and 1975 and the adjusted results, in matrix form, are tabulated in Tables 6 and 7 respectively.

Approximately 25 per cent of the least squares fits chosen from these three functional forms, indicate on the basis of correlation coefficients and standard errors, an unsatisfactory fit. In order to obtain better approximations to the trends of these particular industry-occupational combinations, it will be necessary to use other functional forms which are not strictly monotonic. Coupled with a larger number of matrices and a wider selection of possible functional forms, this should produce stability for all but a very small percentage of the functions constructed from the matrix elements.

Let us now examine the hypothesized stability of the coefficient matrices discussed in the theoretical section. Since we are dealing with only three

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[20] A male matrix with the same industries and occupations as those listed in the 1960 census matrix was constructed by this allocating procedure, and the respective coefficient matrices were then examined for comparability.

TABLE 1

COEFFICIENT MATRIX-DENVER
1940-MALE AND FEMALE

Industry / Occupation		1	2	3	4	5	6	7	8	9	10
		Fab. Metals Indus. (Incl. not Spec. Metal) 34	Machinery Except Electrical 35	Food & Kindred Products 20	Chemicals & Allied Products 28	Rubber & Misc. Plastic Products 30	Utilities & Sanitary Services 49	Wholesale Trade 50	Business Services 73	Medical & Other Health Services 80	Elec. Mach. Equip. & Supplies 36
1.	Designers & draftsmen	1.32	2.77	.37	2.66	2.19	3.08	.41	2.60	22.79	3.36
2.	Civil engineers	2.46	5.16	.68	4.96	4.09	5.74	.76	4.85	42.50	6.27
3.	Industrial engineers	.09	.19	.03	.19	.15	.21	.03	.18	1.59	.23
4.	Bookkeepers	17.76	37.03	27.77	46.90	42.31	39.07	65.11	36.71	17.75	58.79
5.	Office machine operators	2.02	4.21	3.16	5.34	4.81	4.45	7.41	4.18	2.02	6.69
6.	Secretaries	14.26	29.74	22.30	37.66	33.98	31.38	52.28	29.48	14.25	47.21
7.	Stenographers	2.90	6.04	4.53	7.65	6.91	6.38	10.63	5.99	2.90	9.59
8.	Stock clerks & stock keepers	2.76	5.76	4.32	7.30	6.58	6.08	10.13	5.71	2.76	9.15
9.	Telephone operators	2.62	5.45	4.09	6.91	6.23	5.76	9.59	5.41	2.61	8.66
10.	Typists	5.12	10.68	8.01	13.53	12.21	11.27	18.79	10.59	5.12	16.96
11.	Carpenters	34.09	35.10	15.05	6.41	14.71	21.76	3.74	34.03	1.64	14.61
12.	Electricians	10.81	11.13	4.78	2.03	4.67	6.90	1.19	10.79	.52	4.64
13.	Machinists & job setters	23.30	23.99	10.29	4.38	10.05	14.87	2.55	23.26	1.12	9.99
14.	Mechanics & repairmen	59.23	60.98	26.15	11.13	25.56	37.80	6.49	59.12	2.85	25.39
15.	Plumbers & pipe fitters	12.16	12.52	5.37	2.29	5.25	7.76	1.33	12.14	.58	5.21
16.	Stationary engineers	14.26	14.68	6.29	2.68	6.15	9.10	1.56	14.23	.69	6.11
17.	Stationary firemen	3.11	1.53	4.97	2.28	3.79	1.79	1.35	1.13	.30	1.06
18.	Truck drivers & deliverymen	70.24	34.60	112.14	51.40	85.65	40.48	30.56	25.52	6.83	23.94
19.	Charwomen, janitors & porters	2.23	.73	1.90	1.09	.89	2.16	.76	5.54	12.49	.73
20.	Guards, watchmen & doorkeepers	1.38	.45	1.17	.67	.55	1.33	.47	3.43	7.72	.45

TABLE 2

COEFFICIENT MATRIX-DENVER SMA 1950-MALE AND FEMALE

	Industry / Occupation	1 Fab. Metals Indus. (Incl. not Spec. Metal) 34	2 Machinery Except Electrical 35	3 Food & Kindred Products 20	4 Chemicals & Allied Products 28	5 Rubber & Misc. Plastic Products 30	6 Utilities & Sanitary Services 49	7 Wholesale Trade	8 Business Services 73	9 Medical & Other Health Services 80	10 Elec. Mach. Equip. & Supplies 36
1.	Designers & draftsmen	2.24	3.31	.88	3.91	2.97	3.70	1.34	10.08	18.08	3.95
2.	Civil engineers	3.86	5.69	1.51	6.73	5.10	6.37	2.31	17.32	31.08	6.78
3.	Industrial engineers	.41	.60	.16	.71	.54	.67	.24	1.82	3.27	.71
4.	Bookkeepers	11.69	16.50	12.35	16.38	19.67	23.28	26.33	30.61	14.44	19.42
5.	Office machine operators	3.47	4.84	3.66	4.86	5.83	6.90	7.81	9.08	4.28	5.76
6.	Secretaries	17.94	25.33	18.96	25.14	30.19	35.74	40.42	46.99	22.16	29.81
7.	Stenographers	3.65	5.15	3.85	5.11	6.13	7.26	8.21	9.55	4.50	6.06
8.	Stock clerks & stock keepers	3.53	4.98	3.73	4.94	5.94	7.03	7.95	9.24	4.36	5.86
9.	Telephone operators	5.25	7.42	5.55	7.36	8.84	10.46	11.83	13.76	6.49	8.73
10.	Typists	6.45	9.10	6.81	9.04	10.85	12.84	14.52	16.88	7.96	10.71
11.	Carpenters	37.32	46.32	18.64	19.87	18.94	38.17	7.71	9.93	3.00	31.07
12.	Electricians	9.58	11.89	4.78	5.10	4.86	9.79	1.98	2.55	.77	7.97
13.	Machinists & job setters	17.38	21.57	8.68	9.26	8.82	17.77	3.59	4.63	1.40	14.47
14.	Mechanics & repairmen	66.56	82.61	33.23	35.41	33.77	68.06	13.75	17.71	5.36	55.41
15.	Plumbers & pipe fitters	11.15	13.84	5.57	5.94	5.66	11.40	2.30	2.97	.90	9.28
16.	Stationary engineers	9.75	12.10	4.87	5.19	4.95	9.97	2.01	2.59	.78	8.12
17.	Stationary firemen	2.58	1.47	3.70	1.85	3.74	1.21	1.32	.40	.24	1.54
18.	Truck drivers & deliverymen	65.53	37.39	93.82	47.04	94.80	30.71	33.37	10.15	6.05	39.12
19.	Charwomen, janitors & porters	1.38	1.37	32.12	3.41	2.71	1.61	.97	6.76	28.84	1.25
20.	Guards, watchmen & doorkeepers	.65	.65	15.15	1.61	1.28	.76	.46	3.19	13.61	.59

TABLE 3

DERIVED COEFFICIENT MATRIX-DENVER SMSA
1960-MALE AND FEMALE

	Industry Occupation	1	2	3	4	5	6	7	8	9	10
		Fab. Metals Indus. (Incl. not Spec. Metal) 34	Machinery Except Electrical 35	Food & Kindred Products 20	Chemicals & Allied Products	Rubber & Misc. Plastic Products 30	Utilities & Sanitary Services 49	Wholesale Trade 50	Business Services 73	Medical & Other Health Services 80	Elec. Mach. Equip. & Supplies 36
1.	Designers & draftsmen	12.04	6.59	1.10	6.25	3.50	5.03	1.46	6.44	19.90	7.94
2.	Civil engineers	8.92	4.88	.82	4.63	2.59	3.72	1.08	4.77	14.74	5.88
3.	Industrial engineers	4.02	2.20	.37	2.09	1.17	1.68	.49	2.15	8.18	2.65
4.	Bookkeepers	15.84	12.76	10.07	19.32	16.29	20.25	24.61	33.50	6.64	15.65
5.	Office machine operators	7.55	6.08	4.81	9.22	7.70	9.66	11.74	15.98	8.18	7.47
6.	Secretaries	27.38	22.06	17.42	33.41	28.17	35.02	42.56	57.93	29.64	27.07
7.	Stenographers	5.56	4.48	3.54	6.79	5.72	7.12	8.65	11.77	6.02	5.50
8.	Stock clerks & stock keepers	4.59	3.70	2.92	5.60	4.72	5.87	7.14	9.72	4.97	4.54
9.	Telephone operators	5.81	4.68	3.70	7.09	5.98	7.43	9.30	12.29	6.29	5.74
10.	Typists	9.64	7.76	6.13	11.76	9.92	12.33	14.98	20.39	10.43	9.53
11.	Carpenters	22.49	31.10	15.12	13.07	16.24	30.19	8.29	8.08	3.14	19.26
12.	Electricians	8.06	11.15	5.42	4.68	5.82	10.82	2.97	2.90	1.12	6.90
13.	Machinists & job setters	10.44	14.44	7.02	6.07	7.54	14.02	3.85	3.75	1.46	8.94
14.	Mechanics & repairmen	58.96	81.52	39.64	34.26	42.56	79.15	21.73	21.18	8.23	50.48
15.	Plumbers & pipe fitters	8.93	12.35	6.01	5.19	6.45	11.99	3.29	3.21	1.25	7.65
16.	Stationary engineers	9.95	13.75	6.69	5.78	7.18	13.35	3.67	3.57	1.39	8.52
17.	Stationary firemen	1.05	1.27	2.76	1.19	2.66	1.08	.79	.41	.13	1.51
18.	Truck drivers & deliverymen	42.27	51.32	111.28	47.85	107.18	43.58	31.98	16.41	5.30	60.97
19.	Charwomen, janitors & porters	3.09	1.46	3.74	3.64	2.20	2.08	.86	13.54	32.26	.38
20.	Guards, watchmen & doorkeepers	.94	.45	1.14	1.11	.67	.63	.26	4.14	9.86	.12

TABLE 4

MATRIX COEFFICIENT OF CORRELATION AND STANDARD ERROR OF ESTIMATE

	1	2	3	4	5	6	7	8	9	10
1	.957533 .271745	.946753 .120327	.974692 .068354	.998399 .019760	.993599 .021943	.989568 .029153	.919070 .228395	.699565 .402783	.629038 .073834	.940848 .126436
2	.985279 .091246	.358866 .059241	.280545 .326953	.172932 .160086	.661036 .211276	.760213 .151325	.363865 .432594	.046803 .603339	.994805 1.15965	.450193 .052001
3	.993284 .180673	.999381 .035208	.991344 .137114	.999999 .000632	.990899 .056569	.999962 .007419	.998742 .009428	.993562 .308770	.997626 .046161	.998996 .044751
4	.320186 .167184	.973149 .104489	.962649 .118611	.818527 .265364	.961620 .113250	.965665 .073451	.919763 .174093	.552819 .061821	.948212 .134470	.951425 .178499
5	.994687 .055705	.990445 .020892	.985260 .029779	.811457 1.14080	.994493 .020243	.999410 .073069	.913479 .083679	.999478 .017762	.999880 .008869	.455557 .622254
6	.985694 .045539	.999887 .008345	.992656 .012395	.343499 .159179	.781729 .048280	.818813 .032802	.792322 .067808	.987530 .044452	.998190 .018109	.954561 .073205
7	.985971 .044985	.999252 .004722	.992302 .012677	.342732 .159008	.995477 .007417	.822073 .032386	.791326 .068187	.987460 .044574	.998279 .017606	.954875 .072021
8	.999824 .003892	.981005 .035730	.995910 .051855	.707071 .115116	.976294 .030070	.183844 .076724	.987071 .023449	.928967 .088738	.968442 .062844	.995250 .028195
9	.939929 .120834	.324337 .181360	.237248 .167518	.457668 .023031	.095325 .174603	.477004 .214839	.141167 .087912	.838300 .226807	.879585 .200869	.857510 .100729
10	.988058 .040285	.999999 .000190	.997916 .007099	.396377 .153461	.999781 .001780	.715118 .038096	.812780 .011149	.983552 .049731	.999192 .087211	.963016 .067042
11	.769987 .140710	.296212 .159273	.076975 .099477	.622792 .365396	.441276 .093318	.626311 .179667	.927532 .134303	.945210 .207245	.920048 .115985	.415410 .283526
12	.998152 .068354	.023857 .030715	.866025 .029617	.852482 .217199	.938419 .033088	.970134 .046678	.999973 .002729	.854515 .338571	.999910 .004212	.747992 .151815
13	.988090 .051040	.961770 .011102	.997985 .009925	.486199 .267812	.998612 .006187	.238465 .097862	.953406 .054275	.935979 .286987	.949939 .036352	.220204 .200827
14	.033243 .056078	.875535 .067683	.999566 .005021	.882053 .253463	.999989 .000973	.965995 .045184	.996715 .040345	.823350 .301430	.999255 .084853	.839155 .189279
15	.969446 .031893	.109907 .054738	.980136 .009301	.827161 .236660	.983695 .089567	.936137 .068325	.999983 .004715	.870464 .318068	.999666 .007071	.696409 .172188
16	.871265 .085713	.387041 .074009	.209106 .763675	.944143 .111974	.461437 .808459	.957232 .047289	.973424 .082168	.799874 .443640	.936263 .107283	.945608 .047730
17	.962897 .235702	.954919 .032998	.999998 .000469	.992661 .054212	.882095 .077188	.969046 .053430	.888852 .117851	.884034 .226159	.985887 .011785	.871595 .084136
18	.933880 .043723	.943798 .056363	.096098 .081949	.797255 .023179	.998508 .005006	.199970 .147604	.565062 .029634	.528931 .319532	.999936 .007071	.999584 .011009
19	.502921 .603398	.927768 .116737	.285451 1.15531	.914150 .224449	.800558 .289627	.175444 .128526	.555823 .082803	.952373 .116813	.936857 .148062	.547447 .407431
20	.598543 .240416	∼ ∼	.049303 1.21196	.620202 .281839	.279509 .346408	.975495 .069836	.886357 .044783	.699174 .078539	.481846 .203463	.775548 .439233

MATRIX FUNCTIONS

$f_{1,\ 1} = 0.01309e^{0.1105t}$

$f_{1,\ 2} = 0.4495e^{0.0433t}$

$f_{1,\ 3} = -1.0417 + 0.0365t$

$f_{1,\ 4} = 0.4751e^{0.0427t}$

$f_{1,\ 5} = 0.03031t^{1.1640}$

$f_{1,\ 6} = 1.1313e^{0.02452t}$

$f_{1,\ 7} = (3.3835 \times 10^{-6})\ t^{3.2124t}$

$f_{1,\ 8} = (5.2004 \times 10^{-4})\ t^{2.3781t}$

$f_{1,\ 9} = 82.1563t^{-0.36032t}$

$f_{1,\ 10} = 0.5502e^{0.0430t}$

$f_{2,\ 1} = 0.1754e^{0.0644t}$

$f_{2,\ 2} = 6.0159e^{-0.0028t}$

$f_{2,\ 3} = 0.0998t^{0.5763}$

$f_{2,\ 4} = 6.3745e^{-0.0034t}$

$f_{2,\ 5} = 11.8465e^{-0.0228t}$

$f_{2,\ 6} = 15.2097e^{-0.02169t}$

$f_{2,\ 7} = 0.02338t^{1.0181}$

$f_{2,\ 8} = 3.7927t^{0.1705}$

$f_{2,\ 9} = 98.8400 - 1.3880t$

$f_{2,\ 10} = 7.3963e^{-0.0032t}$

$f_{3,\ 1} = -8.318 + 0.1965t$

$f_{3,\ 2} = 0.00138e^{0.1225t}$

$f_{3,\ 3} = (3.246 \times 10^{-12})\ t^{6.244}$

$f_{3,\ 4} = (6.375 \times 10^{-11})\ t^{5.914}$

$f_{3,\ 5} = -1.93 + 0.051t$

$f_{3,\ 6} = (1.270 \times 10^{-9})\ t^{5.1311}$

$f_{3,\ 7} = -0.8967 + 0.023t$

$f_{3,\ 8} = -3.5417 + 0.0985t$

$f_{3,\ 9} = 0.05814e^{0.0819t}$

$f_{3,\ 10} = 0.001679e^{0.1222t}$

$f_{4,\ 1} = 56.1434t^{-0.3409}$

$f_{4,\ 2} = 642{,}764.08t^{-2.6643}$

$f_{4,\ 3} = 305{,}867.40t^{-2.5434}$

$f_{4,\ 4} = 178{,}337.49t^{-2.2803}$

$f_{4,\ 5} = 269{,}215.11t^{-2.3937}$

$f_{4,\ 6} = 16{,}201.31t^{-1.6466}$

$f_{4,\ 7} = 510{,}048.96t^{-2.4606}$

$f_{4,\ 8} = 87.9036t^{-0.2473}$

$f_{4,\ 9} = 139.4934e^{-0.04916t}$

$f_{4,\ 10} = (1.1213 \times 10^{5})\ t^{-2.3698}$

MATRIX FUNCTIONS

$f_{5,\,1} = 0.139e^{0.0659t}$

$f_{5,\,2} = 1.9889e^{0.01878t}$

$f_{5,\,3} = 1.3354e^{0.02101t}$

$f_{5,\,4} = -3.2267 + 0.194t$

$f_{5,\,5} = 1.8503e^{0.02353t}$

$f_{5,\,6} = -6.0217 + 0.2605t$

$f_{5,\,7} = 2.7824e^{0.023009t}$

$f_{5,\,8} = (2.077 \times 10^{-5})\ t^{3.3136}$

$f_{5,\,9} = (6.0508 \times 10^{-6})\ t^{3.4462}$

$f_{5,\,10} = 4.69 + 0.039t$

$f_{6,\,1} = 3.7455e^{0.03262t}$

$f_{6,\,2} = 449.921t^{-0.73612}$

$f_{6,\,3} = 212.6468t^{-0.6134}$

$f_{6,\,4} = 124.313t^{-0.3511}$

$f_{6,\,5} = 41.4053e^{-0.006419t}$

$f_{6,\,6} = 11.3146t^{0.28217}$

$f_{6,\,7} = 355.201t^{-0.5311}$

$f_{6,\,8} = 0.06134t^{1.6816}$

$f_{6,\,9} = 0.01799t^{1.8126}$

$f_{6,\,10} = 7803.1409t^{1.3971}$

$f_{7,\,1} = 0.7642e^{0.03254t}$

$f_{7,\,2} = 10.9422e^{-0.01494t}$

$f_{7,\,3} = 43.0587t^{-0.6126}$

$f_{7,\,4} = 25.1374t^{-0.3499}$

$f_{7,\,5} = 38.7589t^{-0.4687}$

$f_{7,\,6} = 2.3012t^{0.2820}$

$f_{7,\,7} = 72.5182t^{-0.5323}$

$f_{7,\,8} = 0.01247t^{1.6815}$

$f_{7,\,9} = 0.003728t^{1.8075}$

$f_{7,\,10} = 1581.7971t^{-1.3964}$

$f_{8,\,1} = 0.9952e^{0.02543t}$

$f_{8,\,2} = 14.3165e^{-0.02213t}$

$f_{8,\,3} = 7.1567 - 0.07t$

$f_{8,\,4} = 87.8459t^{-0.6942}$

$f_{8,\,5} = 13.0625e^{-0.0166t}$

$f_{8,\,6} = 6.8865e^{-0.001758t}$

$f_{8,\,7} = 247.9621t^{-0.8709}$

$f_{8,\,8} = 0.04260t^{1.3431}$

$f_{8,\,9} = 0.01256t^{1.4727}$

$f_{8,\,10} = 5477.273t^{-1.7383}$

MATRIX FUNCTIONS

$f_{9,\ 1} = 0.001726t^{2.0065}$

$f_{9,\ 2} = 8.4022e^{-0.007616t}$

$f_{9,\ 3} = 5.6261e^{-0.005011t}$

$f_{9,\ 4} = 5.3862t^{0.07150}$

$f_{9,\ 5} = 7.6503e^{-0.002048t}$

$f_{9,\ 6} = 0.4933t^{0.7032}$

$f_{9,\ 7} = 10.8514e^{-0.001535t}$

$f_{9,\ 8} = 0.002669t^{2.1032}$

$f_{9,\ 9} = 0.000765t^{2.240}$

$f_{9,\ 10} = 21.1671e^{-0.02056t}$

$f_{10,\ 1} = 1.4037e^{0.03164t}$

$f_{10,\ 2} = 20.2270e^{-0.01597t}$

$f_{10,\ 3} = 91.7451t^{-0.6622}$

$f_{10,\ 4} = 53.5982t^{-0.3996}$

$f_{10,\ 5} = 80.8893t^{-0.5129}$

$f_{10,\ 6} = 4.8513t^{0.2351}$

$f_{10,\ 7} = 25.6217 - 0.1905t$

$f_{10,\ 8} = 0.02643t^{1.6332}$

$f_{10,\ 9} = -5.4383 + 0.2655t$

$f_{10,10} = 3358.119t^{-1.4451}$

$f_{11,\ 1} = 86.5193e^{-0.0208t}$

$f_{11,\ 2} = 50.0394e^{-0.0605t}$

$f_{11,\ 3} = 91.7451t^{-0.6622}$

$f_{11,\ 4} = 1.9963e^{0.03562t}$

$f_{11,\ 5} = 5.6229t^{0.2768}$

$f_{11,\ 6} = 0.9829t^{0.8705}$

$f_{11,\ 7} = 0.002452t^{2.0102}$

$f_{11,\ 8} = (1.872 \times 10^{7})\ t^{-3.6188}$

$f_{11,\ 9} = 0.004124t^{1.6426}$

$f_{11,10} = 0.9825t^{0.7809}$

$f_{12,\ 1} = 16.3583 - 1.1375t$

$f_{12,\ 2} = 11.3336e^{0.00008977t}$

$f_{12,\ 3} = 3.6407e^{0.006283t}$

$f_{12,\ 4} = 0.0008813t^{2.1362}$

$f_{12,\ 5} = 2.9373e^{0.01101t}$

$f_{12,\ 6} = 0.1117t^{1.1259}$

$f_{12,\ 7} = 0.000289t^{2.2567}$

$f_{12,\ 8} = (2.0955 \times 10^{6})\ t^{-3.3592}$

$f_{12,\ 9} = 0.1124e^{0.03836t}$

$f_{12,10} = 0.1136t^{1.0319}$

MATRIX FUNCTIONS

$f_{13,\ 1} = 120.3208e^{-0.04014t}$

$f_{13,\ 2} = 43.875 - 0.4775t$

$f_{13,\ 3} = 22.2648e^{-0.01912t}$

$f_{13,\ 4} = 0.1886t^{0.8987}$

$f_{13,\ 5} = 17.9331e^{-0.01437t}$

$f_{13,\ 6} = 17.9263e^{-0.00294t}$

$f_{13,\ 7} = 0.05797t^{1.0351}$

$f_{13,\ 8} = (4.5652 \times 10^{8})\ t^{-4.6016}$

$f_{13,\ 9} = 0.09803t^{0.6666}$

$f_{13,10} = 14.3778e^{0.013726t}$

$f_{14,\ 1} = 62.1916e^{-0.000228t}$

$f_{14,\ 2} = 4.1577t^{0.7397}$

$f_{14,\ 3} = 0.5921t^{1.0277}$

$f_{14,\ 4} = 0.00034t^{2.8618}$

$f_{14,\ 5} = 0.2473t^{1.2572}$

$f_{14,\ 6} = -41.705 + 2.0675t$

$f_{14,\ 7} = 0.0001062t^{2.9945}$

$f_{14,\ 8} = (8.2004 \times 10^{5})\ t^{-2.6374}$

$f_{14,\ 9} = -7.97 + 0.269t$

$f_{14,10} = 0.04317t^{1.7613}$

$f_{15,\ 1} = 23.0617e^{-0.01544t}$

$f_{15,\ 2} = 13.3346e^{-0.0006836t}$

$f_{15,\ 3} = 4.2591e^{0.005630t}$

$f_{15,\ 4} = 0.001147t^{2.1008}$

$f_{15,\ 5} = 2.7867 + 0.06t$

$f_{15,\ 6} = 0.1416t^{1.0970}$

$f_{15,\ 7} = -2.5933 + 0.098t$

$f_{15,\ 8} = (2.6986 \times 10^{6})\ t^{-3.3923}$

$f_{15,\ 9} = -0.765 + 0.0335$

$f_{15,10} = 0.1412t^{1.0077}$

$f_{16,\ 1} = 398.653t^{-0.9176}$

$f_{16,\ 2} = 27.9563t^{-0.1874}$

$f_{16,\ 3} = 33.4467 - 0.533t$

$f_{16,\ 4} = 0.002287t^{1.9348}$

$f_{16,\ 5} = 3.5183 + 0.0515t$

$f_{16,\ 6} = 4.0892e^{0.01916t}$

$f_{16,\ 7} = 0.2660e^{0.04278t}$

$f_{16,\ 8} = (5.542 \times 10^{6})\ t^{-3.5659}$

$f_{16,\ 9} = 0.1576e^{0.03502t}$

$f_{16,10} = 0.2875t^{0.8368}$

MATRIX FUNCTIONS

$f_{17,1} = 7.3967 - 0.103t$

$f_{17,2} = 2.0733 - 0.130t$

$f_{17,3} = 16.1104e^{-0.02941t}$

$f_{17,4} = 4.4983 - 0.0545t$

$f_{17,5} = 8.1256e^{-0.0177t}$

$f_{17,6} = 183.8542t^{-1.2648}$

$f_{17,7} = 2.5533 - 0.028t$

$f_{17,8} = 1.3289t^{-2.5797}$

$f_{17,9} = 0.64833 - 0.0085t$

$f_{17,10} = 0.0401t^{0.9022}$

$f_{18,1} = 129.2717 - 1.3985t$

$f_{18,2} = 15.1129e^{0.01971t}$

$f_{18,3} = 126.9433t^{-0.04772}$

$f_{18,4} = 100.0838t^{-0.1846}$

$f_{18,5} = 54.5026e^{0.01121t}$

$f_{18,6} = 31.4644e^{0.00369t}$

$f_{18,7} = 19.8255t^{0.1224}$

$f_{18,8} = 1749.7002t^{-0.01201}$

$f_{18,9} = 9.885 - 0.0765t$

$f_{18,10} = 0.00488t^{2.3017}$

$f_{19,1} = 0.08333 + 0.043t$

$f_{19,2} = 0.001234t^{1.7504}$

$f_{19,3} = 0.001873t^{2.0753}$

$f_{19,4} = (1.61776 \times 10^{-5})\ t^{3.0526}$

$f_{19,5} = (1.95349 \times 10^{-4})\ t^{2.3335}$

$f_{19,6} = 3.3138t^{-0.13814}$

$f_{19,7} = 0.2337t^{0.3339}$

$f_{19,8} = 0.8539e^{0.04468t}$

$f_{19,9} = 0.002018t^{2.3922}$

$f_{19,10} = 3.5935e^{-0.03264t}$

$f_{20,1} = 2.09 - 0.022t$

$f_{20,2} = 0.51667$

$f_{20,3} = 0.66726t^{0.3608}$

$f_{20,4} = 0.005634t^{1.3439}$

$f_{20,5} = 0.0727t^{0.60819}$

$f_{20,6} = 1247.9174t^{-1.8673}$

$f_{20,7} = 0.92167 - 0.0105t$

$f_{20,8} = 2.2272e^{0.009407t}$

$f_{20,9} = 0.729t^{0.6748}$

$f_{20,10} = 8.633e^{-0.06609t}$

TABLE 5

MATRIX OF ADJUSTMENT COEFFICIENTS K_{ij}

	1 Fab. Metals Indus. (Incl. not Spec. Metal) 34	2 Machinery Except Electrical 35	3 Food & Kindred Products 20	4 Chemicals & Allied Products 28	5 Rubber & Misc. Plastic Products 30	6 Utilities & Sanitary Services 49	7 Wholesale Trade 50	8 Business Services 73	9 Medical & Other Health Services 80	10 Elec. Mach. Equip. & Supplies 36
1	1.64037	5.30653	1.34545	.72640	1.21143	2.43738	1.34247	2.33075	.01407	2.37909
2	.83408	2.74590	1.59756	.32613	.32819	4.78226	1.49074	.16143	.06038	-
3	5.31592	1.94091	2.10811	2.17225	6.66666	.70833	.46939	1.07442	.02690	4.41887
4	.30303	.95925	1.69414	.58799	.22898	1.10321	1.53555	.74090	1.66416	.82045
5	.51921	1.05428	1.44699	.53362	2.40000	.96170	.97956	.96308	.32029	.85944
6	1.37582	1.20626	.54478	1.32595	.89066	.50257	1.22580	1.10944	1.52834	1.29775
7	1.94604	2.38393	1.00847	1.56112	.86014	1.50000	1.09711	1.07901	.95515	1.71636
8	1.11983	1.83784	1.13356	.26964	7.54449	1.38160	1.45798	.15844	.43863	.91630
9	.46644	.66453	.44595	.85473	.36789	.63795	.53763	.93979	1.12556	.52613
10	.96058	.87629	.39804	1.03061	.76915	.56123	.70294	2.42521	.76990	1.26863
11	.16229	.15627	.20701	.31905	.04187	.02617	.11098	.26238	.55096	-
12	1.21712	.20897	.59410	.97009	1.07732	1.71719	.38721	.59655	1.74107	.65653
13	2.29981	8.27285	.31054	.81054	3.21618	.38088	.46234	.61600	.34247	2.78859
14	.65027	.61237	.57089	.77379	.78078	1.32634	1.70732	1.28093	.96962	1.16739
15	.85554	.18866	.34775	3.72062	1.55039	2.25938	.50760	.47975	1.33600	.39477
16	5.23317	1.08800	1.78176	2.22664	1.41643	1.55506	.61035	1.13165	4.37410	1.28638
17	.25714	-	.40942	4.77311	1.33835	3.65741	1.02532	3.75610	6.84615	-
18	.19044	.12120	1.00809	.60940	.14555	1.81459	2.00719	1.03169	.34717	.04953
19	2.03560	7.05479	3.63102	2.07967	3.15909	3.80288	3.74419	4.81758	.69529	3.97368
20	12.44685	1.28889	2.14035	8.53153	8.10448	8.79365	7.73077	4.18357	.11359	12.58335

TABLE 6

ADJUSTED COEFFICIENT MATRIX-DENVER SMSA
1970-MALE AND FEMALE

Occupation \ Industry	1 Fab. Metals Indus. (Incl. not Spec. Metal) 34	2 Machinery Except Electrical 35	3 Food & Kindred Products 20	4 Chemicals & Allied Products 28	5 Rubber & Misc. Plastic Products 30	6 Utilities & Sanitary Services 49	7 Wholesale Trade 50	8 Business Services 73	9 Medical & Other Health Services 80	10 Elec. Mach. Equip. & Supplies 36
1. Designers & draftsmen	49.11	49.40	2.03	6.86	5.16	15.36	3.84	29.60	.25	26.55
2. Civil engineers	13.28	13.59	1.84	1.64	.79	15.92	2.64	1.26	.10	5.91
3. Industrial engineers	28.90	14.19	2.28	11.30	10.93	2.64	.33	3.60	.48	38.49
4. Bookkeepers	4.00	7.48	10.50	6.50	2.36	16.37	22.59	22.78	7.44	6.69
5. Office machine operators	7.27	7.81	8.41	5.52	23.06	11.74	13.65	26.00	4.42	6.38
6. Secretaries	49.89	23.79	8.55	37.09	23.53	18.86	46.72	86.21	60.77	26.77
7. Stenographers	14.51	9.17	3.22	173.52	4.55	11.45	8.29	17.04	7.70	7.19
8. Stock clerks & stock keepers	6.61	5.59	2.56	1.24	30.86	8.41	8.94	2.03	2.87	3.12
9. Telephone operators	4.05	3.28	1.77	6.24	2.44	6.25	5.24	19.05	11.69	2.64
10. Typists	12.35	5.79	2.19	10.11	7.04	7.39	8.64	66.11	10.12	9.18
11. Carpenters	3.27	.11	1.14	7.71	.76	1.04	1.39	1.03	2.44	27.11
12. Electricians	8.19	2.38	3.36	7.47	6.84	22.92	1.63	.79	2.87	5.98
13. Machinists & job setters	16.67	86.45	1.81	6.95	21.10	5.56	2.18	.91	.57	101.45
14. Mechanics & repairmen	39.80	58.97	26.61	50.16	40.31	136.64	60.76	14.30	10.53	89.57
15. Plumbers & pipe fitters	6.70	2.40	2.20	32.07	10.84	33.82	2.17	1.09	2.11	4.03
16. Stationary engineers	42.28	13.72	-	18.90	10.08	24.32	3.24	1.65	8.00	12.94
17. Stationary firemen	.05	-	.84	3.26	3.15	3.12	.61	-	.36	1.86
18. Truck drivers & deliverymen	5.98	7.28	104.49	27.84	17.39	73.93	66.94	11.37	1.57	4.27
19. Charwomen, janitors & porters	6.29	14.74	45.82	14.43	12.48	7.00	3.61	93.89	36.38	1.46
20. Guards, watchmen & doorkeepers	6.85	.66	6.61	14.50	7.80	3.94	1.45	17.99	1.46	1.07

TABLE 7

ADJUSTED COEFFICIENT MATRIX-DENVER SMSA
1975-MALE AND FEMALE

Occupation \ Industry		1 Fab. Metals Indus. (Incl. not Spec. Metal) 34	2 Machinery Except Electrical 35	3 Food & Kindred Products 20	4 Chemicals & Allied Products 28	5 Rubber & Misc. Plastic Products 30	6 Utilities & Sanitary Services 49	7 Wholesale Trade 50	8 Business Services 73	9 Medical & Other Health Services 80	10 Elec. Mach. Equip. & Supplies 36
1.	Designers & draftsmen	85.33	61.34	2.29	8.48	5.58	17.35	4.79	34.87	.24	32.93
2.	Civil engineers	18.32	13.40	1.92	1.61	.70	14.30	2.83	1.28	-	5.82
3.	Industrial engineers	34.13	26.18	3.50	17.01	12.60	3.76	.39	4.14	.73	70.92
4.	Bookkeepers	3.91	6.23	8.83	5.56	2.00	14.62	19.06	22.39	5.81	5.32
5.	Office machine operators	10.11	8.57	9.35	6.04	25.94	13.00	15.31	32.68	5.61	6.55
6.	Secretaries	59.50	22.61	8.20	36.07	22.78	19.23	43.96	96.82	68.87	24.31
7.	Stenographers	17.07	8.51	3.09	177.76	4.40	11.67	7.99	19.13	8.72	6.54
8.	Stock clerks & stock keepers	7.50	5.00	2.17	1.18	28.37	8.34	8.41	2.23	3.18	2.76
9.	Telephone operators	4.66	3.16	1.72	6.27	2.41	6.55	5.20	22.03	13.65	2.38
10.	Typists	14.47	5.35	2.09	9.84	6.79	7.51	7.96	73.99	11.14	8.31
11.	Carpenters	2.95	.08	1.09	9.21	.78	1.10	1.60	.81	2.73	28.61
12.	Electricians	7.36	2.38	3.46	8.66	7.23	24.78	1.91	.63	3.48	6.42
13.	Machinists & job setters	13.64	66.68	1.65	7.40	14.03	5.48	2.34	.66	.60	108.39
14.	Mechanics & repairmen	39.76	62.06	28.57	61.11	36.62	150.35	74.70	11.91	11.84	101.14
15.	Plumbers & pipe fitters	6.19	2.39	2.26	37.09	11.30	36.47	2.42	.87	2.34	4.32
16.	Stationary engineers	39.72	13.55	-	21.62	10.45	26.76	4.02	1.29	9.54	13.71
17.	Stationary firemen	-	-	.72	1.96	2.88	2.86	.46	-	.07	1.97
18.	Truck drivers & deliverymen	4.64	8.03	104.15	27.49	18.39	75.31	67.51	10.29	1.44	5.00
19.	Charwomen, janitors & porters	6.74	16.65	52.87	17.80	14.66	6.96	3.70	117.36	42.91	1.24
20.	Guards, watchmen & doorkeepers	5.48	.67	6.78	15.95	8.10	3.46	1.04	18.87	1.53	.76

points in this analysis, monotonic functions having two degrees of freedom are the only functions considered in this initial run. Later, when matrices are constructed for 1930 and 1920, other functional forms such as cubic, parabolic, the Gompertz curve, the Logistic curve and others will be considered.

Stability can be clearly seen for the three point regressions by observing the correlation coefficients and standard errors of estimate in Table 4. The upper values (correlation) in most cases exceed 0.7 whereas the corresponding standard errors are all very close to zero. This means that there is a highly correlated trend in the coefficients of these matrices which in turn reflects stable, structural industry-occupational employment trends in the Denver economy.

Industry Production and Output Functions

The primary problem in implementing these two aspects of the model was collecting the necessary employment and output time series data for the Denver SMSA. Once the data had been compiled, it was a routine matter to fit various curves by the method of least squares and choose the best fits for the required employment and output functions.

Ideally we would have liked to obtain data which would measure output as adjusted sales and employment in man-hours over a consecutive ten-year period prior to 1963. The year 1963 was chosen as the base year for the projection since complete data were not yet available for 1964.

For several two-digit manufacturing industries, we were able to use data compiled in the Annual Survey of Manufactures.[21] There was a major change in the Standard Industrial Classification System beginning in 1958, and this change required the use of data from 1958 on for the sake of consistency. In fact, the S.I.C. change carried over to all data sources using this classification, and limited us to the same time interval for all of our data sources.

The concept of output used in the Annual Survey of Manufactures which is closest to our desired measure of output is "value added." There are two measures of value added -- "value added" and "adjusted value added." The use of adjusted value added began in the Annual Survey of Manufactures in 1956; unadjusted value added was discontinued in 1958, making comparison among prior and subsequent time periods difficult. Value added is obtained by subtracting the cost of materials, supplies and containers, fuel, purchased electrical energy, and contract work from the value of shipments for products manufactured plus receipts for services rendered. Adjusted value added is the same concept modified by: (a) value added by merchandising operations (the difference between the sales value and cost of merchandise sold without further manufacture, processing or assembly), and (b) the net change in finished goods and work-in-process inventories between the beginning and end of the year.

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[21] U. S. Census of Manufactures, U. S. Department of Commerce, Bureau of the Census.

Two types of employment are listed: (1) total number of workers, and (2) total production workers. We chose total number of workers since man-hour figures are not available.

For certain manufacturing industries we were able to obtain the necessary ordered pairs required for the employment and output functions solely from the Census of Manufactures. For non-manufacturing, we investigated the following Department of Commerce publications: (1) Census of Mineral Industries Final Reports, and (2) Census of Business Final Reports, for both retail and wholesale trade and selected services.[22] These data sources were published only for the years 1954 and 1958, and in the future will be published for 1963. We were able to use information taken from these sources only as benchmarks in adjusting other sources of data.

The widest industry coverage of total employment and wage data was collected and compiled by the Colorado State Department of Employment. The primary difficulty with these data is its inclusion of only those firms covered by the Federal-State unemployment compensation program. Therefore, none of the public sectors are included, nor are small firms employing fewer than four employees. Since firms with fewer than four employees are significant in the Denver SMSA, it was necessary to adjust these data upward through the use of the benchmarks mentioned above to obtain a reasonably complete estimate of total industry employment in the SMSA.

The state data are collected quarterly for approximately eighty two-digit S.I.C. industries. It was necessary to average the quarterly data to obtain total annual employment. Also, employment is measured as total number of employees reported by each firm and is subject to the multiple counting discussed earlier.

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[22] United States Bureau of the Census, Census of Mineral Industries: Final Reports, 1958, Vol. II, Area Statistics; Census of Business: Final Reports, 1958, Vol. II; Retail Trade, Area Statistics, Vol. IV; Wholesale Trade, Area Statistics, Vol. VI; Selected Services, Area Statistics.

The benchmark adjustments on wages and employees were made as follows: Data obtained from the sources indicated as well as data obtained from Employment and Earnings Statistics published by the U. S. Department of Labor and the Census of Population[23] were used to calculate scale factors for both wages and employment for various benchmark years.[24] These scale factors, which are the ratios of benchmark employment and wage figures to corresponding figures taken from the state employment data, are used to adjust the state employment figures for all the required years, 1958-1963. In using these scale factors, we assume homogeneous wage rates and comparable factors of production between reporting and non-reporting firms under the Employment Security program.

Various combinations of these data sources gave the necessary ordered pairs of employment versus output, and output versus time for the years 1958-1963. A discussion of the detailed difficulties involved in interpreting and reconciling these data will not be attempted here. Nevertheless, these problems were met and decisions were made so as to produce meaningful ordered pairs of employment, output, and time.

The functional forms -- linear, parabolic, cubic, geometric, and exponential -- were fitted to each of the sets of ordered pairs, (E^t, X^t) and (X^t, t) respectively. Examination of correlation coefficients and standard errors determined the best fits for the above functions. The measures of fit for all the trial functions are listed in Table 8; the regressions finally chosen for each industry's production and output functions are shown in Table 9.

Using these employment and output functions, reference forecasts of employment and output for 1970 and 1975 were made (see Table 10). The output functions were evaluated and plotted for the years 1964-1978 and are given in Graphs 1-10. These graphs and reference forecasts form the base from which the final industry-output-expansion path combinations are determined.

The final phase of the numerical application was to determine the most probable combinations of industry expansion paths. And the final industry employment projections are based on these combinations and the projected and

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[23] Employment and Earnings Statistics for States and Areas, 1939-63, U. S. Department of Labor, Bureau of Labor Statistics; U. S. Census of Population, op. cit.

[24] It was not possible to use the same benchmark years for all industries. In fact, in some cases it was necessary to average several scale factors.

TABLE 8

	Curve Type / SIC Code	COEFFICIENT OF CORRELATION					STANDARD ERROR OF ESTIMATE				
		Linear	Parabola	Cubic	Exponential	Geometric	Linear	Parabola	Cubic	Exponential	Geometric
INDUSTRY PRODUCTION FUNCTION	34	.952345	.941653	.419637	.949094	.960470	.074574	.105648	1.236571	.019822	.017518
	35	.739417	.693176	.375192	.743376	.758909	.067849	.111534	1.793451	.018456	.017968
	20	.897459	.884137	.521643	.895127	.911075	.130943	.076547	.156379	.011280	.010430
	28	.876191	.651437	.239559	.771643	.591912	.062262	.118463	.947272	.147255	.198563
	30	.824302	.716389	.346549	.826208	.821197	.085227	.054111	.151399	.016224	.016434
	49	.985369	.965132	.793147	.988617	.979781	.039894	.071567	.176543	.009469	.012591
	50	.991046	.979347	.653496	.989322	.993189	.144327	.020165	1.239416	.006575	.005256
	73	.998978	.989617	.513649	.998442	.999021	.042272	.009456	2.765194	.010660	.008450
	80	.998038	.801007	.715634	.999035	.996136	.081790	.019326	1.915641	.004173	.008346
	36	.493798	.876542	.429364	.450551	.944282	.959825	.143528	1.001346	.120082	.020504
OUTPUT-TIME FUNCTION	34	.982765	.956491	.565477	.975671	.978149	.504294	.036159	1.771756	.026095	.024742
	35	.962733	.924317	.484917	.953377	.956393	.597646	.051665	2.113651	.032468	.031424
	20	.995707	.977543	.399176	.991556	.992629	.661784	.013564	3.371562	.014386	.013444
	28	.912823	.694561	.777851	.714165	.711079	.018061	.054963	.118654	.023318	.023423
	30	.894127	.876514	.717561	.891007	.895683	.722841	.017651	1.651641	.024467	.023974
	49	.999524	.977658	.314561	.998274	.998819	.089443	.009917	2.937165	.007445	.006160
	50	.996057	.976514	.400165	.991775	.993039	1.177179	.017651	1.236510	.013562	.012480
	73	.988304	.971654	.399416	.981542	.983417	.714717	.015641	3.175641	.044555	.042251
	80	.993936	.987563	.417654	.998037	.997588	.601807	.010961	3.115637	.009715	.010767
	36	.593816	.771764	.443785	.569862	.869733	2.082925	.123961	.913527	.139050	.039065

TABLE 9

INDUSTRY PRODUCTION AND OUTPUT FUNCTIONS

	Industry	S.I.C. Code	Production Function	Output Function
1.	Fabricated Metals Industries (Incl. not Spec. Metal)	34	Geometric: $E = 0.803X^{0.508}$	Exponential: $X = (0.395)\ (1.07)^t$ $= 0.395e^{0.0675t}$
2.	Machinery Except Electrical	35	Geometric: $E = 2.041X^{0.195}$	Exponential: $X = (0.748)\ (1.06)^t$ $= 0.748e^{0.0553t}$
3.	Food & Kindred Products	20	Geometric: $E = 4.99X^{0.208}$	Exponential: $X = (1{,}805)\ (1.06)^t$ $= 1.805e^{0.0593t}$
4.	Chemical and Allied Products	28	Linear: $E = 1.799 - 0.061759X$	Linear: $X = 1.079 + 0.107486t$
5.	Rubber and Miscellaneous Products	30	Exponential: $E = (3.565)\ (1.012)^X$ $= 3.565e^{0.012X}$	Geometric: $X = 0.0292t^{1.70}$
6.	Utilities and Sanitary Services	49	Exponential: $E = (2.239)\ (1.022)^X$ $= 2.239e^{0.0215X}$	Linear: $X = -79.574 + 1.697t$
7.	Wholesale Trade	50	Geometric: $E = 3.122X^{0.423}$	Exponential: $X = (3.061)\ (1.063)^t$ $= 3.061e^{0.0615t}$
8.	Business Services	73	Geometric: $E = 0.366X^{0.869}$	Exponential: $X = (0.00624)\ (1.143)^t$ $= 0.00624e^{0.134t}$
9.	Medical & Other Health Services	80	Exponential: $E = (7.356)\ (1.019)^X$ $= 7.356e^{0.0185X}$	Exponential: $X = (0.0065)\ (1.148)^t$ $= 0.0065e^{0.1385t}$
10.	Electrical Machinery Equipment & Supplies	36	Geometric: $E = 0.52279X^{0.35316}$	Geometric: $X = (8.097455X10^{-7})t^{4.0887}$

TABLE 10

INDUSTRY OUTPUT-EMPLOYMENT REFERENCE FORECASTS 1970-1975

	Industry	S.I.C. Code	Year	Industry Output[a]	Industry Employment[b]
1.	Fabricated Metals (Including not Spec. Metal)	34	1958	19,402,000	3,573
			1963	26,917,000	4,220
			1970	44,528,544	5,524
			1975	62,404,063	6,557
2.	Machinery Except Electrical	35	1958	17,714,000	3,520
			1963	23,583,000	3,785
			1970	35,896,783	4,103
			1975	74,330,153	4,330
3.	Food and Kindred Products	20	1958	55,139,000	11,346
			1963	74,872,000	12,109
			1970	114,612,920	13,379
			1975	154,170,710	14,230
4.	Chemical and Allied Products	28	1958	7,291,000	1,385
			1963	8,116,000	1,287
			1970	8,603,020	1,268
			1975	9,140,450	1,235
5.	Rubber and Miscellaneous Plastic Products	30	1958	27,866,000	4,985
			1963	32,508,000	5,105
			1970	39,999,036	5,761
			1975	44,976,637	6,116
6.	Utilities and Sanitary Services	49	1958	18,857,000	3,405
			1963	27,306,000	4,070
			1970	39,216,000	5,203
			1975	47,701,000	6,244
7.	Wholesale Trade	50	1958	106,561,000	22,423
			1963	146,353,000	25,629
			1970	226,725,850	30,961
			1975	308,351,890	35,261
8.	Business Services	73	1958	14,326,000	3,719
			1962	25,961,000	6,294
			1970	73,937,841	15,400
			1975	114,492,110	27,567
9.	Medical and Other Health Services	80	1960	26,658,000	12,100
			1963	40,252,000	15,500
			1970	105,535,544	51,828
			1975	210,934,350	364,236
10.	Electrical Machinery Equipment and Supplies	36	1958	12,276,000	1,113
			1962	19,254,000	1,514
			1970	28,340,008	1,703
			1975	37,576,095	1,882

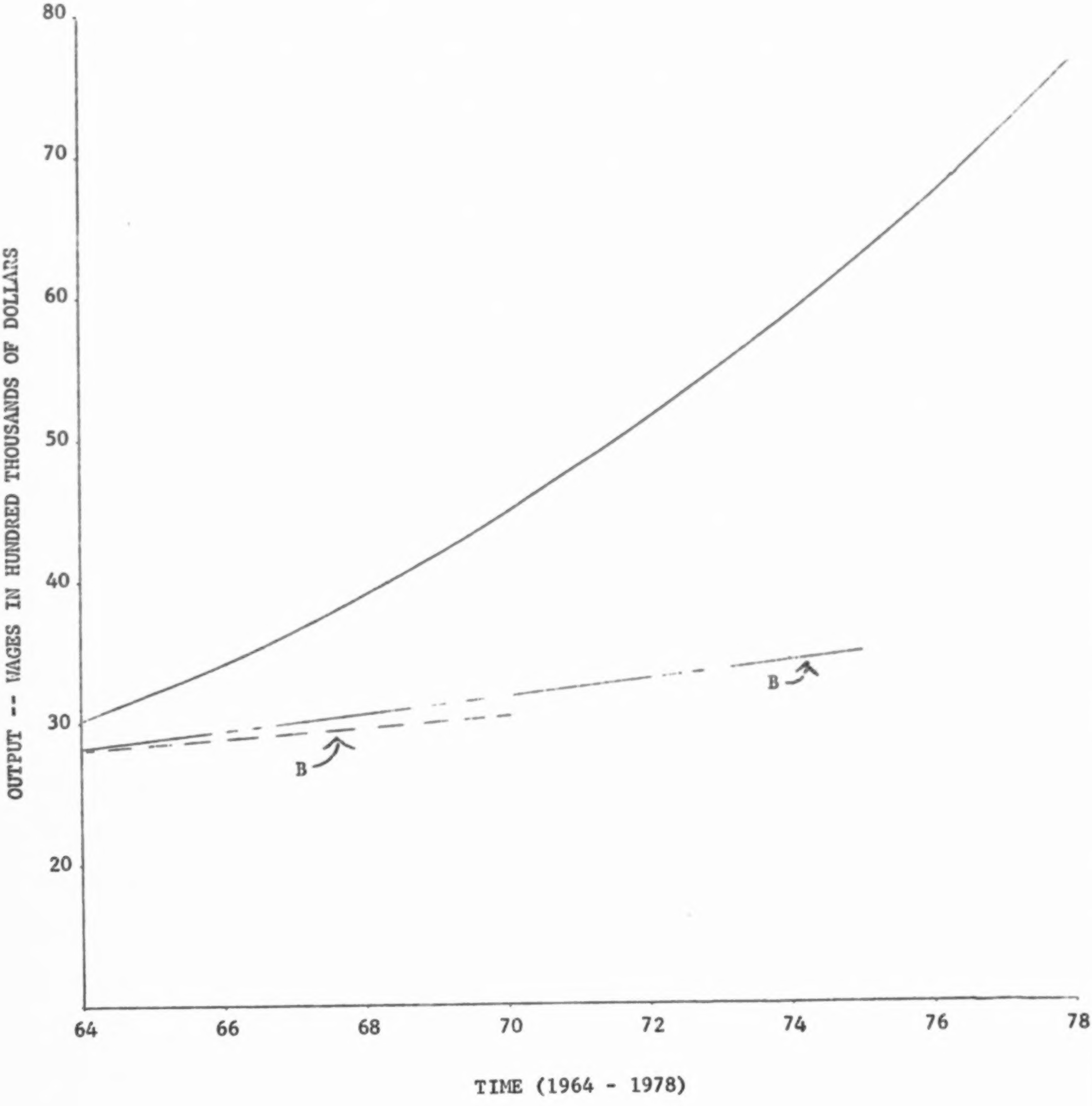
[a] Output is measured in total wages except for industry 10 which is in adjusted value added.

[b] Employment is measured as total employees.

GRAPH 1

OUTPUT FUNCTION -- FABRICATED METAL INDUSTRIES (INCLUDING NOT SPECIFIED METAL)

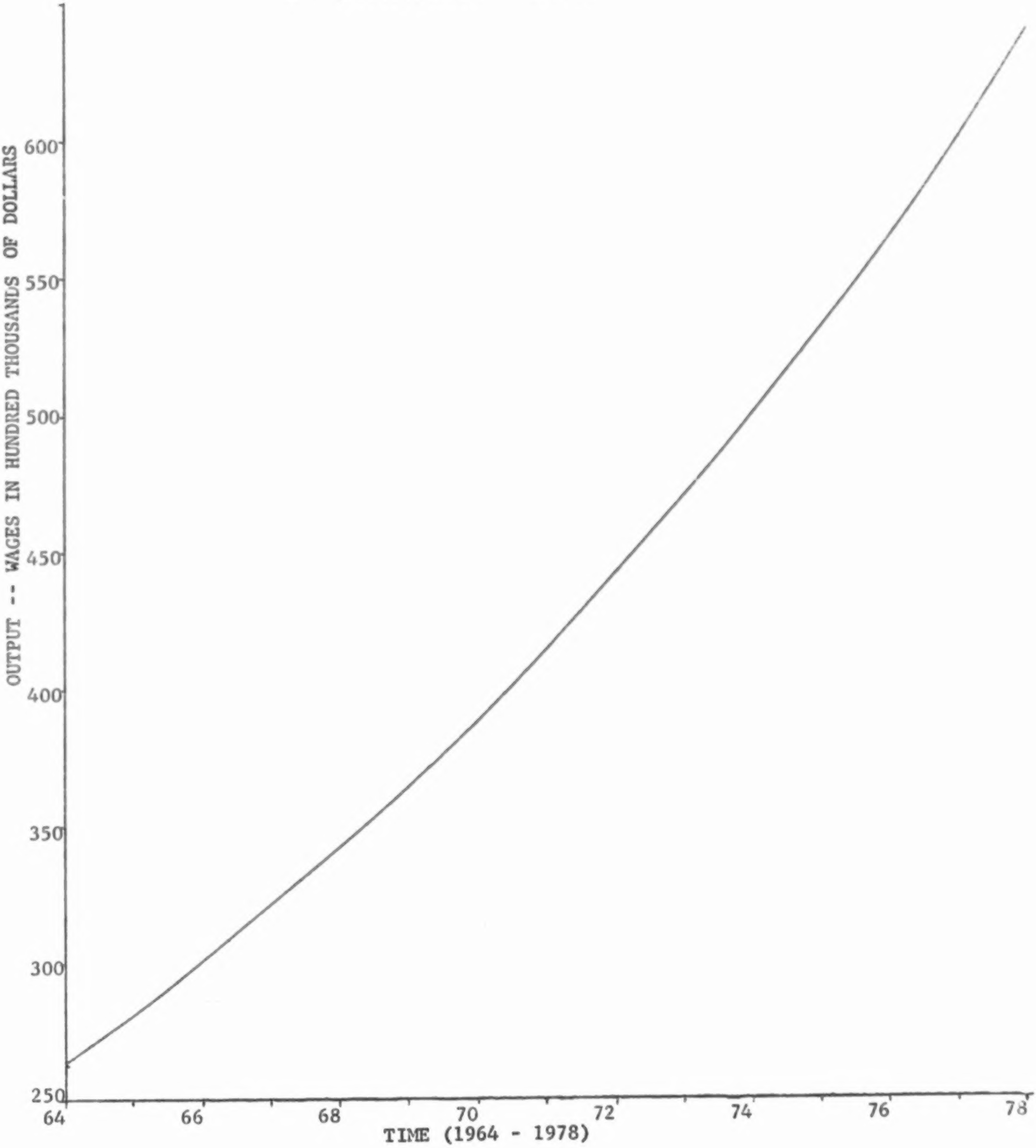
$$X = 0.395e^{0.0675t}$$



GRAPH 2

OUTPUT FUNCTION -- MACHINERY EXCEPT ELECTRICAL

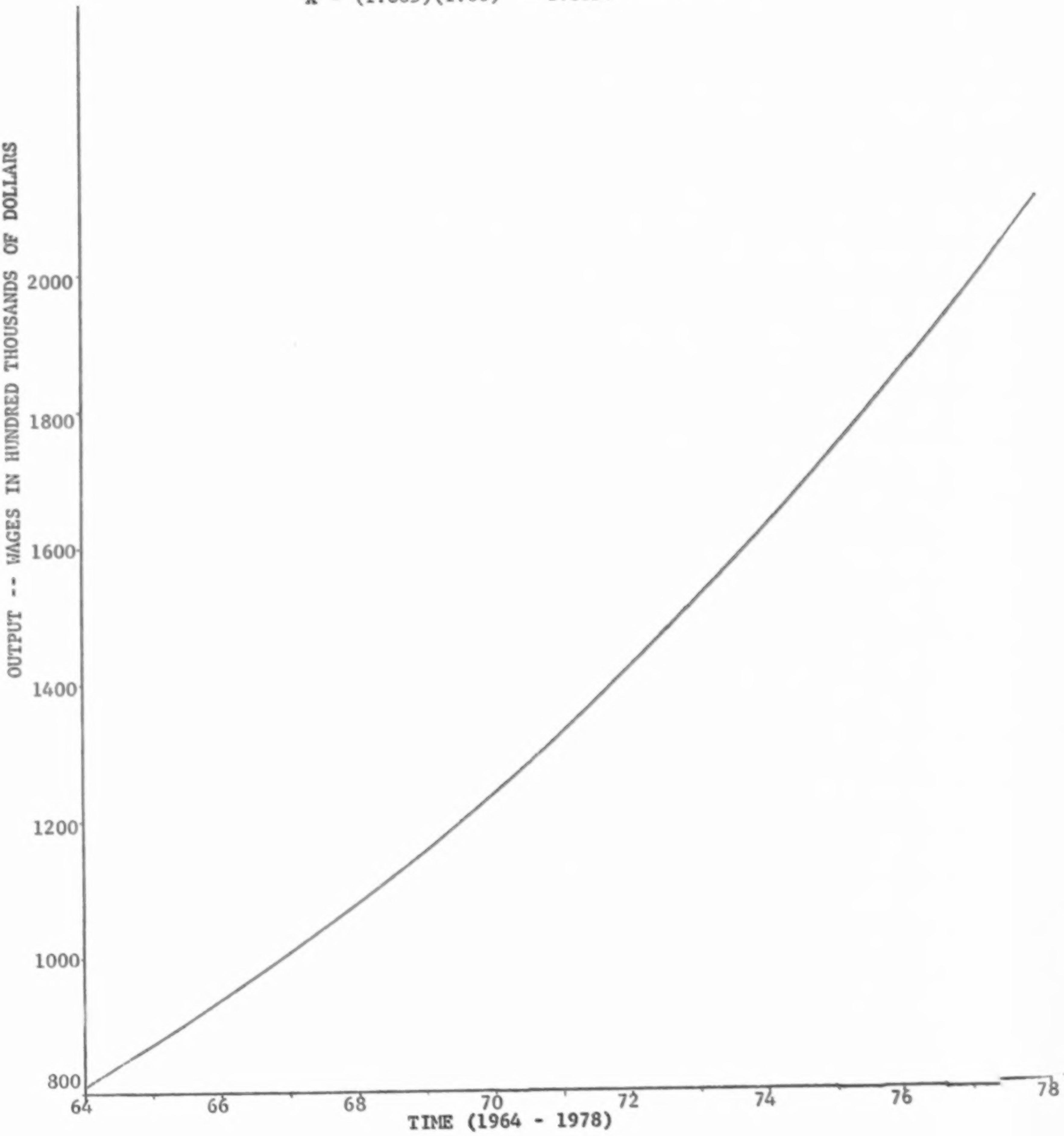
$$X = (0.748)(1.06)^t = 0.748e^{0.0553t}$$



GRAPH 3

OUTPUT FUNCTION -- FOOD AND KINDRED PRODUCTS

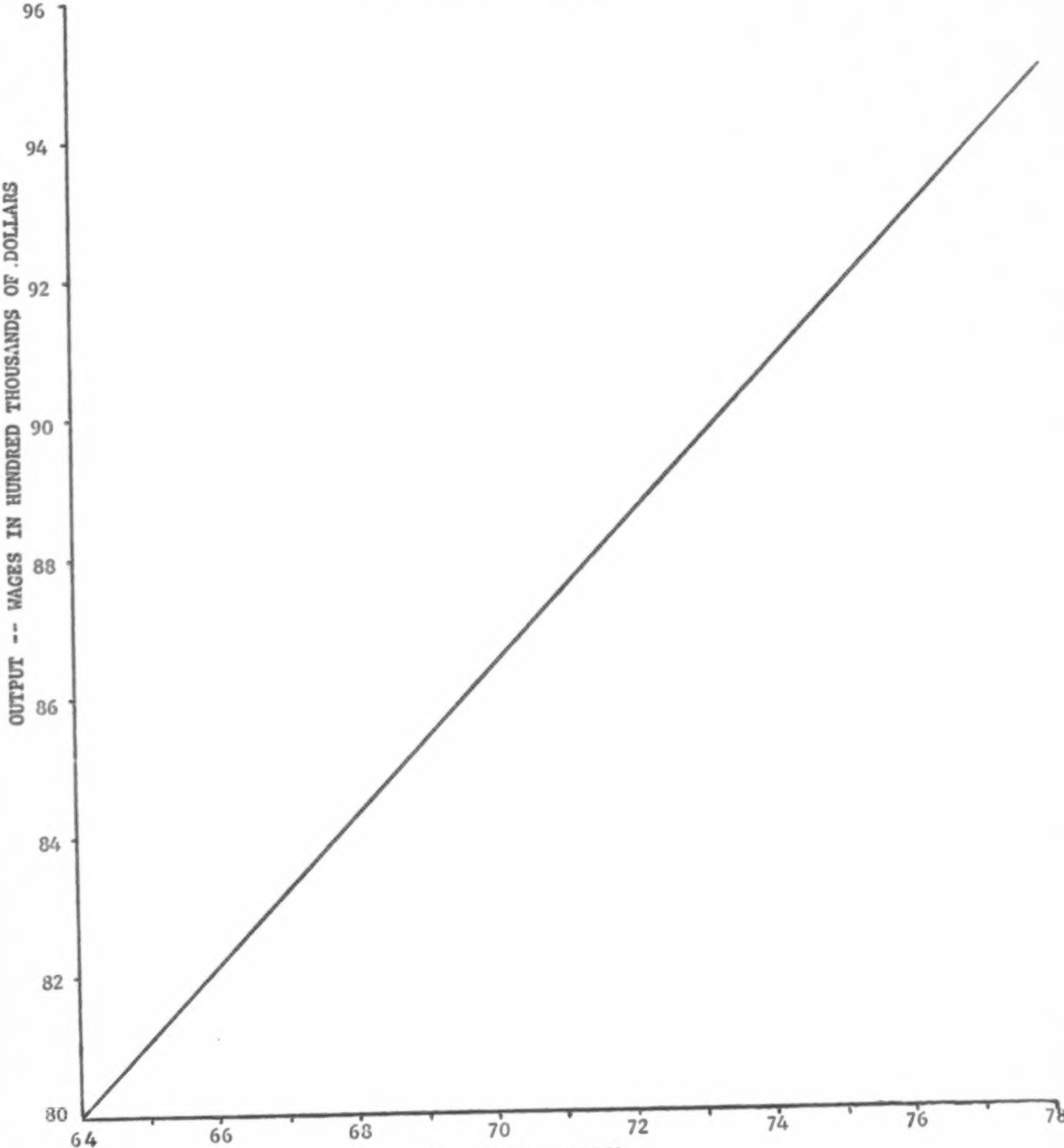
$$X = (1.805)(1.06)^t = 1.805e^{0.0593t}$$



GRAPH 4

OUTPUT FUNCTION -- CHEMICAL & ALLIED PRODUCTS

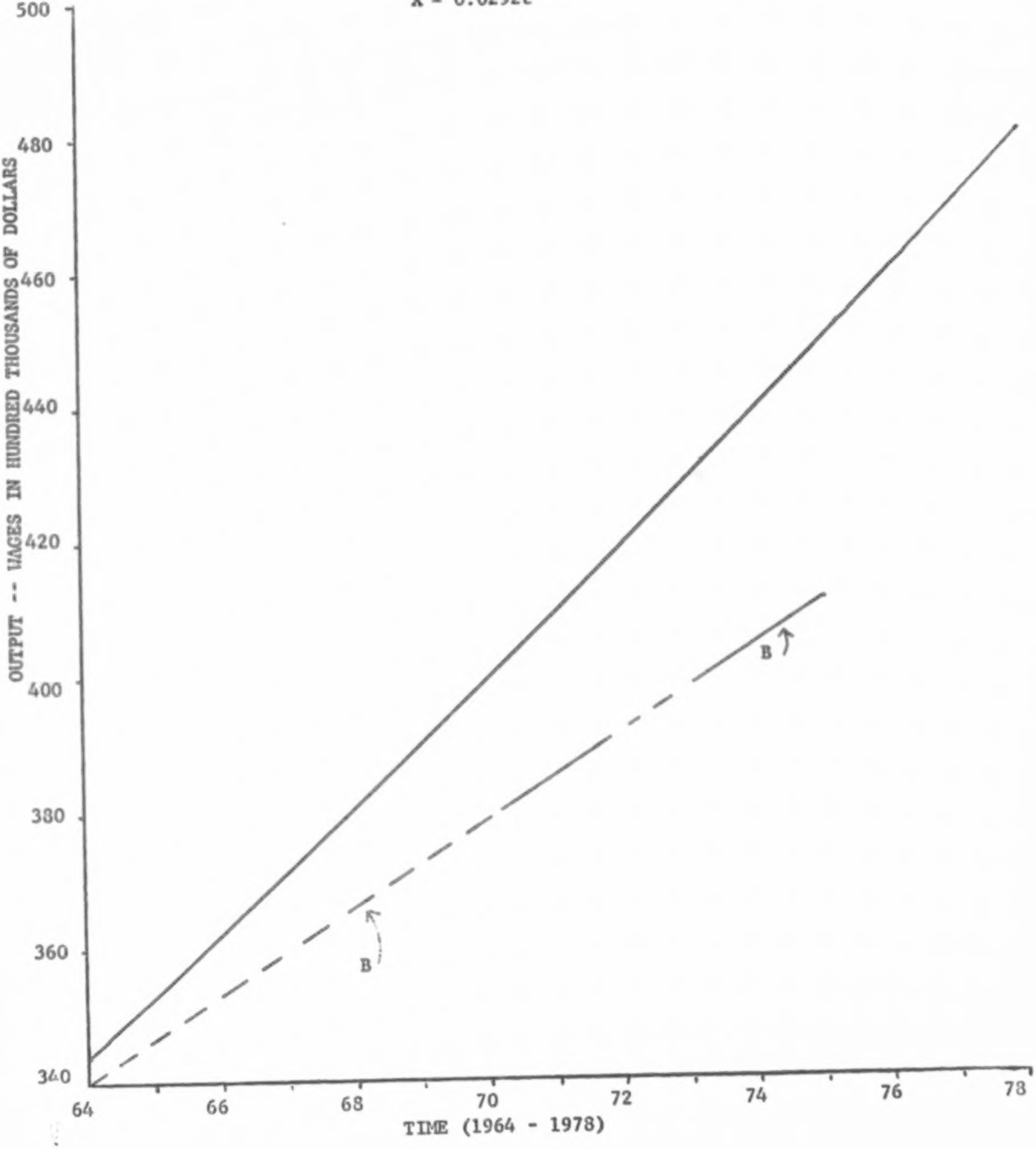
$X = 1.079 + 0.107486t$



GRAPH 5

OUTPUT FUNCTION -- RUBBER AND MISCELLANEOUS PLASTIC PRODUCTS

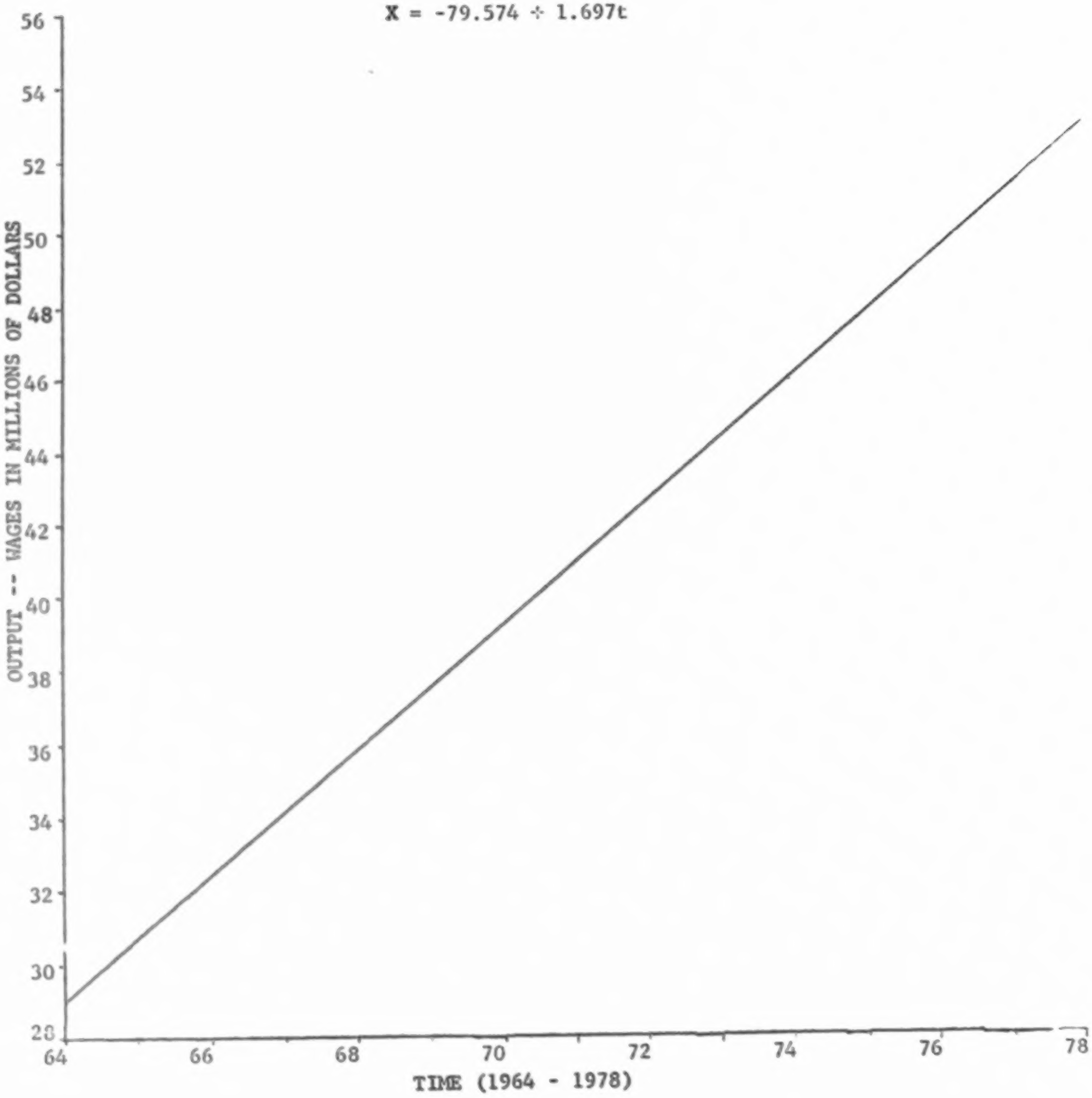
$X = 0.0292t^{1.70}$



GRAPH 6

OUTPUT FUNCTION -- UTILITIES AND SANITARY SERVICES

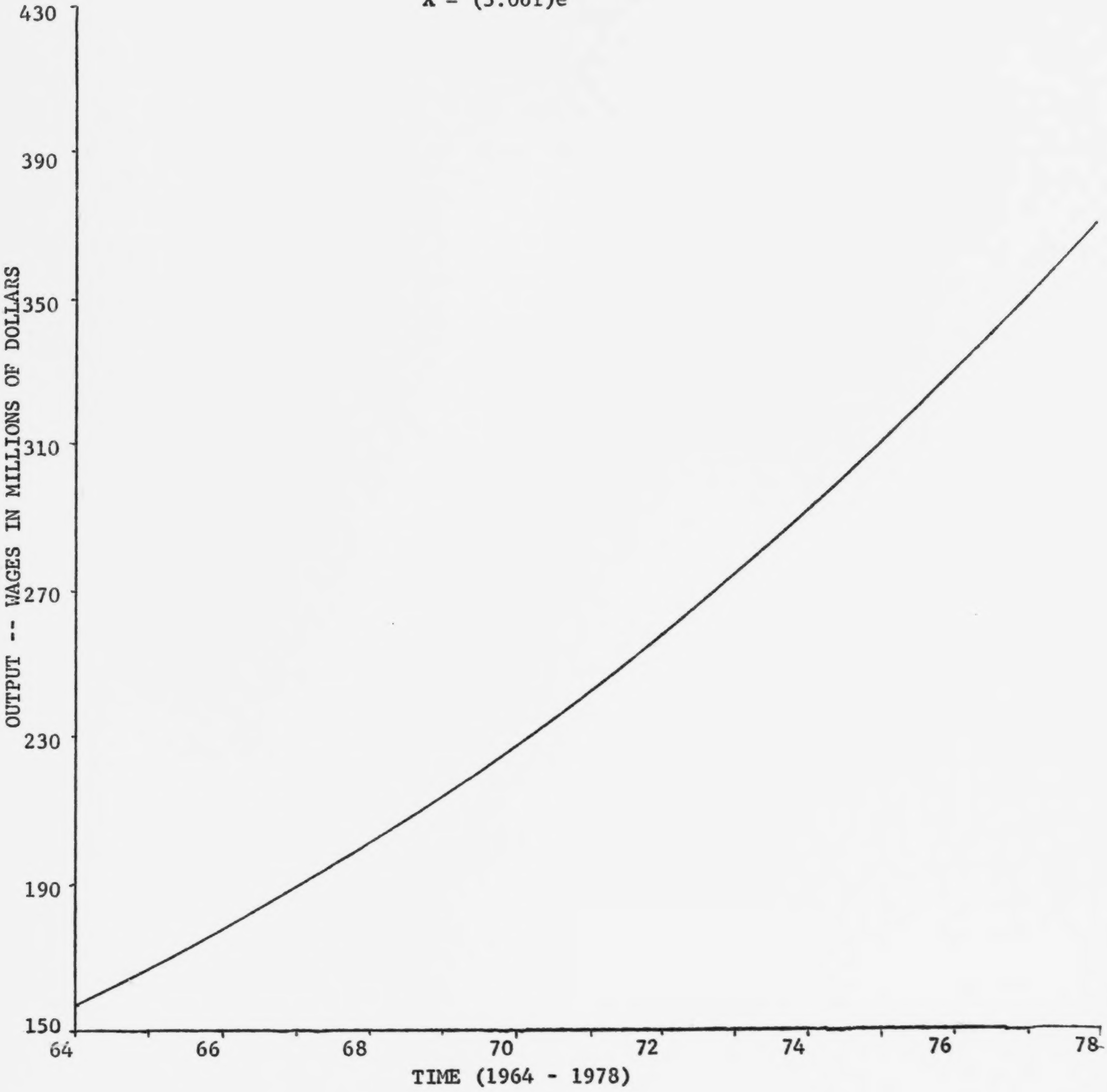
$X = -79.574 + 1.697t$



GRAPH 7

OUTPUT FUNCTION -- WHOLESALE TRADE

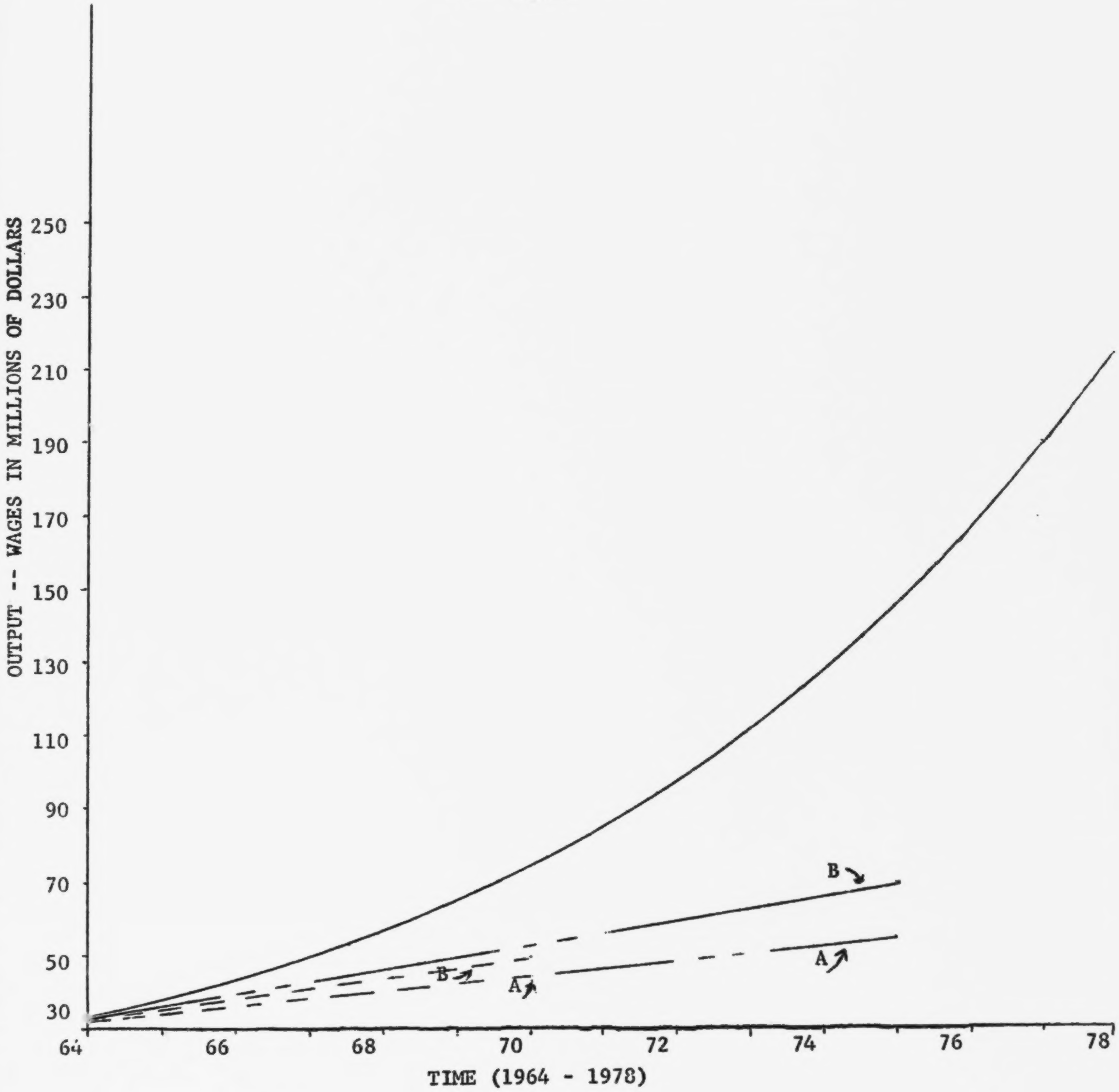
$$X = (3.061)e^{0.0615t}$$



GRAPH 8

OUTPUT FUNCTION -- BUSINESS SERVICES

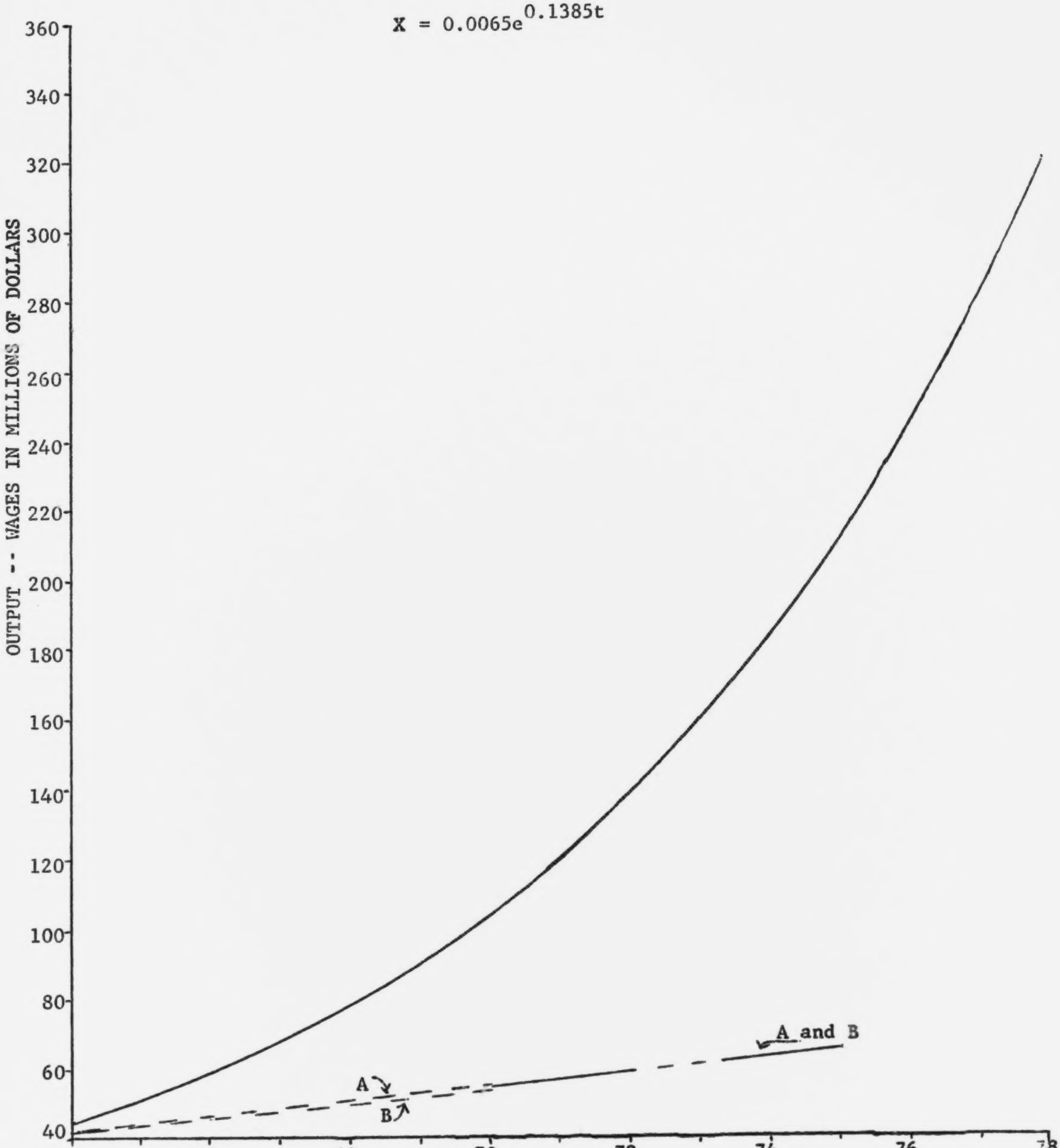
$$X = 0.0624e^{0.134t}$$



GRAPH 9

OUTPUT FUNCTION -- MEDICAL AND OTHER HEALTH SERVICES

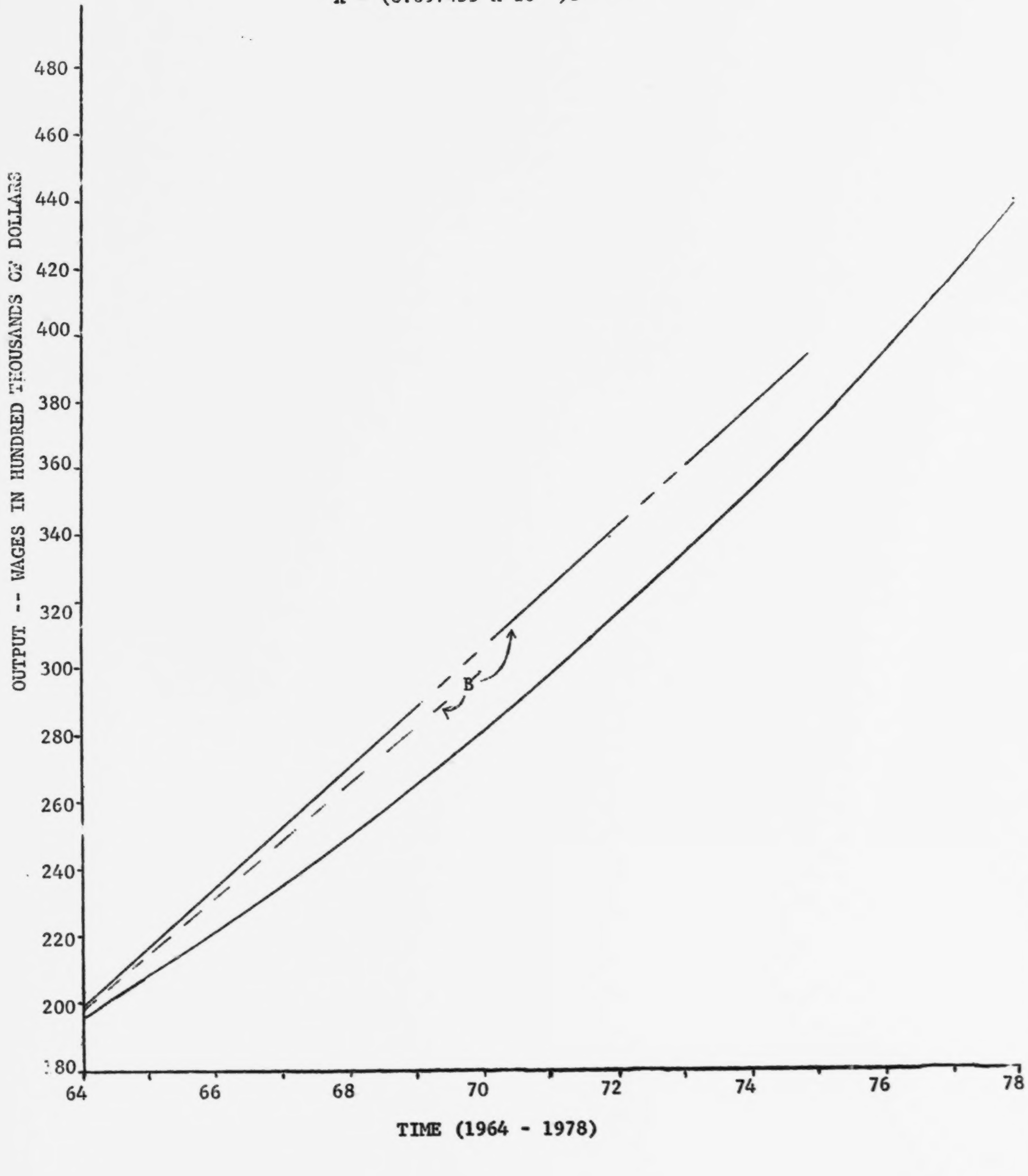
$X = 0.0065e^{0.1385t}$



GRAPH 10

OUTPUT FUNCTION -- ELECTRICAL MACHINERY, EQUIPMENT AND SUPPLIES

$$X = (8.097455 \times 10^{-7})t^{4.0887}$$



adjusted coefficient matrices. From these, the projected occupational-employment levels are derived.

The Occupational-Employment Forecasts

The first step in obtaining forecasts of occupational employment levels is to determine which of the ten industries included in the forecasting schedule can be considered stable export industries. These decisions were made on the basis of the stability of the output versus time schedules of the various industries as well as their growth patterns. The unstable industries are characterized by occasional shifts in their output versus time schedules in a manner different from the expected patterns of stable export industries following national trends and serving national markets. The growth rates and fluctuations of these unstable industries tend to respond primarily to factors unique to the local region.[25]

The two industries which obviously will deviate significantly from the trend of their output functions are Business Services and Medical and Other Health Services. This can be seen in Table 10, which shows both industries approximately doubling their outputs every five years. This abnormally high growth rate is caused by the large autonomous government expenditure in space and space-related activities in the Denver area which created in its wake an accelerated demand for both local health and business services. These accelerated growths cannot be expected to continue indefinitely and therefore it is necessary to deviate significantly from the projected output functions in determining the probable future expansion paths for these industries.

Examples of stable industries in this forecasting schedule are Machinery Except Electrical, Utilities and Sanitary Services, and Wholesale Trade. These industries show a high degree of stability through both national and local fluctuations. It is possible to extrapolate directly from their respective output functions in the determination of their future output levels.

In cases where it is necessary to deviate from the derived output function, an average growth rate (output per year) is computed from the observed years most representative of those industries' future growth patterns. For example, Fabricated Metal Industries, which had an output in 1962 of \$23,704,000 and an output in 1958 of \$19,402,000, had an average growth rate of

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[25] "Unstable industry" is used to designate any industry which is expected to deviate significantly from its output function. One class of unstable industries are those depending primarily upon local demand -- sometimes called subsidiary industries. Another class includes those industries which are carrying out autonomous investment plans over the period of observation.

$$\frac{\$4,302,000}{5} = \$860,400 \text{ per year.}$$

The expected output in 1970 and 1975, on the basis of this rate of growth, would be

$$8 \times (\$860,400) + \$23,704,000 = \$30,588,000 \text{ in 1970, and}$$

$$13 \times (\$860,400) + \$23,704,000 = \$34,889,200 \text{ in 1975.}$$

The future industry employment levels are computed from the industry production function,

$$E = 0.803(X)^{0.508} .$$

These employment levels are 4,482 and 4,953 employees respectively.

Two combinations of probable expansion paths, designated A and B, are determined for all ten industries through 1970 and 1975. In combination A, all future industry output values are determined by direct extrapolation of the output functions, $h_j(t)$, with the exception of Business Services and Medical and Other Health Services. The future output levels of the latter two industries was computed in the manner described above. In combination B, the future output values of all but the very stable industries 2, 3, 6 and 7 are altered from their extrapolated values by estimated average growth rates computed over what were considered representative growth periods for these industries. The outputs of industries 2, 3, 6 and 7 are determined by direct extrapolation on their output functions. These output combinations and their associated industry employment levels are summarized in Table 11.

The employment columns in Table 11 corresponding to output combinations A and B for the years 1970 and 1975 are the V vectors discussed earlier, and when multiplied by the adjusted coefficient matrices for these respective years they determine the individual occupational employment level forecasts. The final forecasts are summarized in Table 12.

TABLE 11

Industry Employment-Output Forecast Combinations

Output Employment Combination / Industry	1970				1975			
	A		B		A		B	
	Output[a]	Employment[b]	Output	Employment	Output	Employment	Output	Employment
1. Fabricated metals (including not spec. metal)	44.529	5.524	30.588	4.482	62.404	6.557	34.889	4.953
2. Machinery except electrical	35.897	4.103	35.897	4.103	74.330	4.330	74.330	4.330
3. Food and kindred products	114.613	13.379	114.613	13.379	154.171	14.230	154.171	14.230
4. Chemical and allied products	8.603	1.268	7.691	1.324	9.141	1.235	7.806	1.317
5. Rubber and miscellaneous plastic products	39.999	5.761	37.947	5.619	44.977	6.116	41.832	5.889
6. Utilities and sanitary services	39.216	5.203	39.216	5.203	47.701	6.244	47.701	6.244
7. Wholesale trade	226.726	30.961	226.726	30.961	308,352	35.261	308.352	35.261
8. Business services	44.521	9.025	51.306	11.023	56.121	12.182	71.100	14.880
9. Medical and other health services	55.564	19.996	53.650	19.856	65.134	24.423	65.134	24.423
10. Electrical machinery equipment and supplies	28.340	1.703	30.422	1.747	37.576	1.882	37.402	1.879

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[a] The measure of output is total wages except for industry 10 which is measured in adjusted value added. All output figures are expressed in millions of dollars.

[b] Employment is measured as total number of employees. All employment figures are expressed in thousands.

TABLE 12

	Occupation	Occupational Employment Forecasts				Census Occupational-Employment Levels in 1960
	Output Combination	1970		1975		
		A	B	A	B	
1.	Designers & draftsmen	1,056	1,064	1,672	1,629	755
2.	Civil engineers	348	337	427	401	341
3.	Industrial engineers	457	435	724	679	462 (Male Only)
4.	Bookkeepers	1,365	1,406	1,385	1,440	1,513
5.	Office machine operators	1,142	1,183	1,571	1,638	684 (Female Only)
6.	Secretaries	4,254	4,365	5,366	5,529	3,303 (Female Only)
7.	Stenographers	1,043	1,071	1,252	1,290	726 (Female Only)
8.	Stock clerks & stock keepers	675	667	635	723	643 (Male Only)
9.	Telephone operators	686	719	922	974	410 (Male Only)
10.	Typists	1,295	1,413	1,718	1,894	928 (Female Only)
11.	Carpenters	201	200	245	243	192 (Male Only)
12.	Electricians	393	386	490	478	413 (Male Only)
13.	Machinists & job setters	890	876	840	817	1,296 (Male Only)
14.	Mechanics & repairmen	4,198	4,185	5,433	5,398	2,966 (Male Only)
15.	Plumbers & pipe fitters	481	477	587	580	471 (Male Only)
16.	Stationary engineers	796	754	993	932	1,381 (Male Only)
17.	Stationary firemen	79	79	70	69	111
18.	Truck drivers & deliverymen	4,195	4,210	4,714	4,733	3,254 (Male Only)
19.	Charwomen, janitors & porters	2,524	2,699	3,634	3,938	1,204
20.	Guards, watchmen & doorkeepers	451	479	531	473	438 (Male Only)

Since the primary purpose of this preliminary report is to develop a forecasting method and simultaneously to establish the data sources and methods of data reconciliation necessary to implement the technique, the forecasts are restricted to only two industry expansion path combinations. These two expansion combinations are not necessarily the best choices although they are certainly reasonable. They were chosen mainly for the purpose of illustrating the general working of the technique. The point to be emphasized is that the occupational forecasts are integrally dependent upon the aggregate growth patterns and their associated future output levels, particularly for those industries which can be expected to deviate significantly from their short-run trends.

If this method is applied in an inclusive form to the entire economic complex of an SMSA, a much more extensive investigation should be made of the region. This investigation should include interviews with the heads of leading firms in the region and consultation with such organizations as the local Chamber of Commerce. It should also include an extensive compilation of historical data.

In combination A (Table 12) for 1970 we assume that all industries will maintain their current growth trends except Business, and Medical and Health Services. Under this assumption, there will be a total demand for 1,056 designers and draftsmen in these industries in 1970, an increase of 301 over 1960. As another example consider output combination B for 1975. Here we applied a number of judgments based on what was considered to be typical growth periods for these industries to obtain reasonable future output combinations. Under these conditions, the demand for bookkeepers will decrease by 73 employees in these industries. In fact, bookkeepers will decrease from the 1960 level under both combinations in each of the years 1970 and 1975.

Table 12 shows that occupational employment levels do not necessarily follow a monotonic trend. For example, consider Civil Engineers under output combination B. In 1960, there were 341 civil engineers distributed throughout the ten industries. In 1970, the number decreases to 337, whereas in 1975 it increases to 401. In any of the "proportional" methods the employment forecasts would show either strictly increasing, decreasing, or constant trends and would not account for the oscillations so commonly observed in various occupational-employment figures.

This oscillations phenomenon is not unusual when one considers that the coefficient matrix is a function of time and that each element is in turn a distinct function possessing a unique rate of change through time. Therefore, any row in the coefficient matrix evaluated at some point in time will have a distinct set of coefficients reflecting the occupational allocation among all the industries. However, the same row evaluated at another point in time can show an entirely different occupational allocation because of a changing industry mix. Hence, this continuously changing industry-occupation structure can conceivably result in wide deviations in the net rate of change of the total occupational employment level.

Total industry employment trends may have overall increases while a row of coefficients may show a net decrease. In this case, the total occupational employment level corresponding to this row may increase, decrease, or even oscillate over a series of time periods.

In summary, the occupational employment trends are dependent not only upon the relative rates of change of the individual elements in the functional coefficient matrix but also upon the time variation of the industry employment vector and its interaction with the respective rows of this matrix. Thus, it is not surprising that we observe in the application of this method fluctuations in some projected occupational employment levels over a series of time periods under a given output combination. In fact, this is exactly the type of phenomena that can be observed in any real situation and is precisely the type of result that a realistic method should predict.

IV

CONCLUSIONS

In general, the technique developed here appears to be feasible, and to warrant further investigation. Two of the major assumptions upon which the method rests are the stability of the coefficient matrices and the industry production functions. There is stability in more than 75 per cent of the matrix elements and a considerably higher percentage could be obtained with more matrices and a wider selection of functional forms. Investigation along these lines should be continued.

Most of the industry production functions show a high degree of stability. However, the use of total wages as a measure of output introduced an element of error since changes in wages reflect many factors other than changes in production. Further investigation may reveal other sources of output which will eliminate the errors introduced by using wages as a surrogate for output.

Two other factors should be considered in any future application of this method. They are possible shifts in production functions due to radical changes in the productive techniques of prominent firms in an industry, and the measurement of all money variables in real terms. An investigation of investment rates in the various industries should lead to a more representative set of production functions. Data on wage rates and price changes should be helpful in establishing price indices to measure output in real terms. It should thus be possible to anticipate and better formulate the approximate future production functions of all industries; even those in which productive relationships experience radical changes.

Since the initial statistical implementation of this method, the authors have derived a mathematical procedure for collectively projecting coefficient matrices. Provided a residual occupational category is included, the sum of the coefficients in each industry column should always equal one. However, if each element is projected independently, there is no guarantee that projected column sums will indeed equal one. A technique has been devised by which matrix functions are determined in such a manner that the individual elements are continuously interdependent throughout each of the columns and such that the column sums equal one at any future time period. In future application of this method it would be advantageous to apply this interdependent curve fitting technique. This was a pilot study, and modifications similar to the one above were discovered too late to be included in the statistical implementation of the model. Further research will undoubtedly lead to additional refinements which should improve this method as a forecasting tool.